THAMES RIVER BASIN

STAFFORD, CONNECTICUT

WARREN POND DAM
00335

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

The original hardcopy version of this report contains color photographs and/or drawings. For additional information on this report please email

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DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS. 02154

AUGUST 1980

DISPOSITION FORM

For use of this form, see AR 340-15, the proponent agency is TAGCEN.

REFERENCE OR OFFICE SYMBOL	SUBJECT
NEDED-E c	Dam Safety Draft Report CNHN

TO: Chief, Design Branch
Chief, Geotechnical Engrg. Branch
Chief, Water Control Br.

FROM: Chairman, Dam Safety Review Board

DATE 28MAY80 CMT 1

Attached for your review are two copies of the Architect-Engineer's draft report for WARREN POND Dam, Identity No. CT 00335. The review board meeting date for this report is 5 JUNE 80 (THR) Please present your comments in writing under the format shown below. Please return one copy with your comments. Cost code for this rewiew is ABAO / 070 / 000000 (FY80)

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5/29/80

NATIONAL PROGRAM OF INSPECTION OF NON-FEDERAL DAMS
DRAFT REPORT REVIEW COMMENTS
WARREN POND DAM, IDENTITY NO. CT00335
GEOTECH. ENGRG. BRANCH

Page No.	Comments
1, 9 & 13	change rating to FAIR as on p 8 Par 3.1a

5/H/G* "Y. Now"

GEOTECHNICAL ENGINEERING BRANCH

RECEIVED
MAY 28 1980
Geotech. Engrg. Br.

NOTE: Bring nine (9) copies of comments to review board meeting.

FORM 1 FEB 72 2496 REPLACES DD FORM 96, WHICH IS OBSOLETE. ☆GPO—1976-

407-441

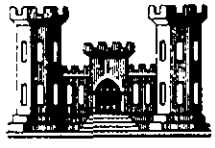
THAMES RIVER BASIN

STAFFORD, CONNECTICUT

WARREN POND DAM
00335

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM



DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS. 02154

AUGUST 1980

BRIEF ASSESSMENT

PHASE I INPSECTION REPORT

NATIONAL PROGRAM OF INSPECTION OF DAMS

Name of Dam:	WARREN POND DAM
Inventory Number:	CT 00335
State Located:	CONNECTICUT
County Located:	TOLLAND
Stream:	FURNACE BROOK
Owner:	WARREN CORPORATION
Date of Inspection:	MARCH 24, 1980
Inspection Team:	PETER HEYNEN, P.E.
	HECTOR MORENO, P.E
	MIRON PETROVKSY
	THEODORE STEVENS
	ROBERT JAHN

The project, built around 1852, has a total length of approximately 293 feet, consisting of a 113 foot long, broad-crested masonry spillway between two 90 foot long embankments with masonry downstream faces (See Sheet B-1). The top of the embankments, at elevation 519.0, are approximately 14 feet wide and 3 feet above the spillway crest. The dam is 22 feet in height above the streambed of Furnace Brook and, with the pond level to the top of the dam, impounds approximately 105 acre-feet of water. At the right end of the dam is a canal leading to the Warren Corporation mill downstream. The inlet to the canal is a 6 foot wide by 5.5 foot deep masonry arch culvert.

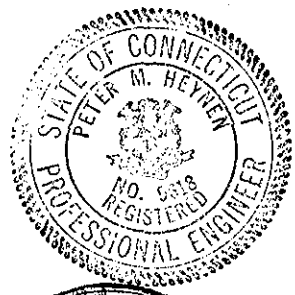
Based upon the visual inspection at the site and past performance, the project is, judged to be in fair condition. No evidence of instability of the project was observed. However, there are items which require maintenance and/or evaluation, such as deteriorated masonry at several locations on the dam and the absence of a low-level outlet for the dam.

In accordance with the Army Corps of Engineer's Guidelines, Warren Pond Dam is classified as a high hazard, small size dam. The test flood range to be considered is from one-half to full Probable Maximum Flood (PMF). The test flood for Warren Pond Dam is equivalent to the 1/2 PMF. Peak inflow to the reservoir at the 1/2 PMF is 12,000 cubic feet per second (cfs); peak outflow is 12,000 cfs with the dam overtopped by 4.7 feet. The spillway capacity, with the reservoir level to the top of the dam, is 1,900 cfs, which is equivalent to 16% of the routed test flood outflow.

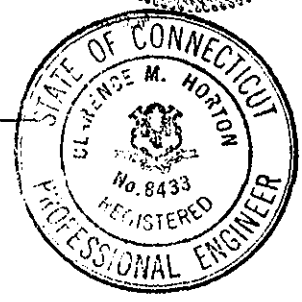
It is recommended that the owner retain the services of a registered professional engineer to perform a more detailed hydraulic/hydrologic analysis of the adequacy of the existing project discharge. Other items of importance are repair of deteriorated masonry and evaluation of existing outlet facilities. Recommendations made by the engineer should be implemented by the owner.

The above recommendations and further remedial measures presented in Section 7 should be instituted within one year of the owner's receipt of this report.

Peter M. Heynen, P.E.
Project Manager - Geotechnical
Cahn Engineers, Inc.



C. Michael Horton, P.E.
Department Head
Cahn Engineers, Inc.



This Phase I Inspection Report on Warren Pond Dam has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgment and practice, and are hereby submitted for approval.

ARAMAST MAHTESIAN, MEMBER
Geotechnical Engineering Branch
Engineering Division

CARNEY M. TERZIAN, MEMBER
Design Branch
Engineering Division

RICHARD DIBUONO, CHAIRMAN
Water Control Branch
Engineering Division

APPROVAL RECOMMENDED:

JOE B. FRYAR
Chief, Engineering Division

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspection. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I Investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam would necessarily represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions will be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test Flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions there of. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as neccessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

The Phase I Investigation does not include an assessment of the need for fences, gates, no-trespassing signs, repairs to existing fences and railings and other items which may be needed to minimize trespass and provide greater security for the facility and safety to the public. An evaluation of the project for compliance with OSHA rules and regulations is also excluded.

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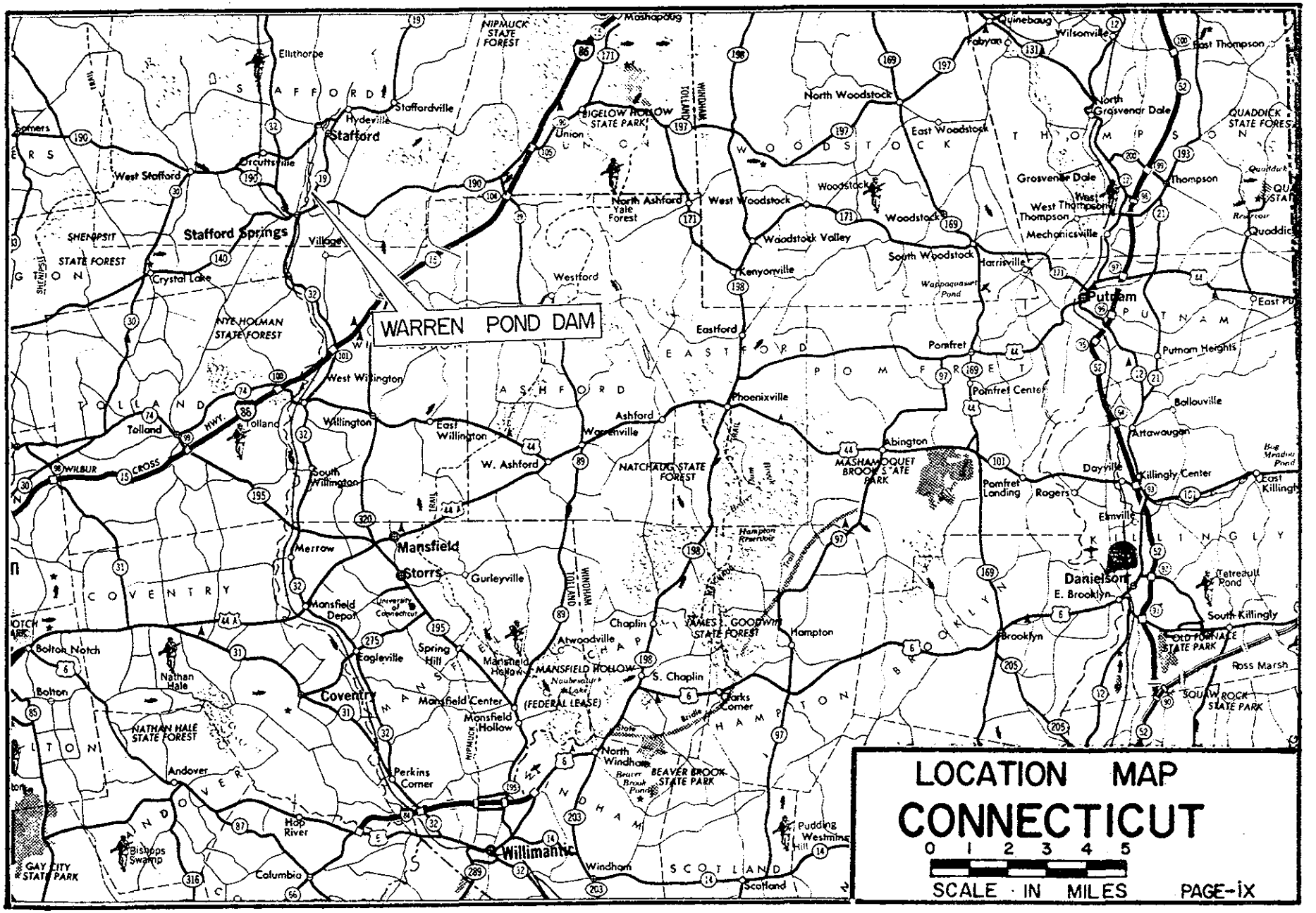
February, 1980

US ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.	NATIONAL PROGRAM OF	Warren Pond Dam Furnace Brook Stafford, Conn.
CAHN ENGINEERS INC. WALLINGFORD, CONN. ENGINEER	INSPECTION OF NON-FED. DAMS	CE #27 785 KA DATE May '80 PAGE viii


WARREN POND DAM
LOCATION MAP
CONNECTICUT
0 1 2 3 4 5
SCALE IN MILES
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PHASE I INSPECTION REPORT

WARREN POND DAM

SECTION I - PROJECT INFORMATION

1.1 GENERAL

a. Authority - Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a National Program of Dam Inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. Cahn Engineers, Inc. has been retained by the New England Division to inspect and report on selected dams in the State of Connecticut. Authorization and notice to proceed were issued to Cahn Engineers, Inc. under a letter of April 14, 1980 from William E. Hodgson, Jr. Colonel, Corps of Engineers. Contract No. DACW 33-80-C 0052 has been assigned by the Corps of Engineers for this work.

b. Purpose of Inspection Program - The purposes of the program are to:

1. Perform technical inspection and evaluation of non-federal dams to identify conditions requiring correction in a timely manner by non-federal interests.

2. Encourage and prepare the States to quickly initiate effective dam inspection programs for non-federal dam.

3. To update, verify and complete the National Inventory of Dams.

c. Scope of Inspection Program - The scope of this Phase I inspection report includes:

1. Gathering, reviewing and presenting all available data as can be obtained from the owners, previous owners, the state and other associated parties.

2. A field inspection of the facility detailing the visual condition of the dam, embankments and appurtenant structures.

3. Computations concerning the hydraulics and hydrology of the facility and its relationship to the calculated flood through the existing spillway.

4. An assessment of the condition of the facility and corrective measures required.

It should be noted that this report does not pass judgement on the safety or stability of the dam other than on a visual basis. The inspection is to identify those features of the dam which need corrective action and/or further study.

1.2 DESCRIPTION OF PROJECT

a. Location - The dam is located on Furnace Brook in a rural area of the Town of Stafford, County of Tolland, State of Connecticut. The dam is shown on the Stafford Springs USGS Quadrangle Map, having coordinates latitude N41°57.6' and longitude W72°18.0'.

b. Description of Dam and Appurtenances - As shown on Sheet B-1, the approximately 22 foot tall dam is a stone masonry and earthfill gravity structure. The dam is approximately 293 feet long, consisting of a 113 foot long masonry spillway centered between two earthfill embankments, each approximately 90 feet in length. Near the right end of the dam are two sluice gate openings to a masonry arch culvert and a canal leading to the Warren Corporation factory downstream.

The spillway, at elevation 516 is a broad-crested masonry weir of trapezoidal cross-section with a shallow gravel bottom approach channel and a downstream face at an approximately 6 to 1 batter. Spillway discharge is onto a concrete and stone splash apron, where boulders have been placed as a baffle for energy dissipation. Masonry training walls extend upstream from the spillway, separating it from the embankments to either side.

The right and left embankments each consist of an upstream earthfill with a downstream masonry face at a batter of approximately 6 to 1. The tops of the embankments are a minimum of 3 feet above the spillway crest and gradually slope up towards the end abutments of the dam. The top of each embankment is grass covered and approximately 14 feet wide. The upstream slopes, at inclinations of approximately 3 horizontal to 1 vertical are protected by mortared riprap, except for the extreme right end of the dam, where erosion protection consists of dumped boulders.

Two sluice gate openings, located near the right end of the dam, are approximately 3 feet wide by 5.5 feet deep and feed a 6 foot wide stone arch culvert to the canal. No sluice gates or operating mechanism to control flow to the canal are in place. The approximately 5 foot deep canal is lined by masonry walls along its left side to a distance of approximately 65 feet from the dam and by an earth bank along its right side. Approximately 75 feet downstream of the dam is a 12 inch diameter cast iron drain pipe through the left canal wall. No operating mechanism for this outlet is in place, though mountings on the canal wall are in place.

c. Size Classification - (SMALL) - The dam impounds 135 acre-feet of water with the reservoir level to the top of the dam, which at elevation 519.0, is 22 feet above the streambed of Furnace Brook. According to recommended guidelines, a dam with maximum storage between 50 and 1,000 acre-feet is classified as small in size.

d. Hazard Classification - (HIGH) - If the dam were breached, there is potential for loss of more than a few lives and extensive property damage to residential, commercial and industrial buildings, including a post office and a sewage treatment plant, in an approximately 4000 foot reach through Stafford Springs (See Sheet D-1 & Page D-7).

e. Ownership - The Warren Corporation
Mr. William L. Sorensen, Treasurer
99 Furnace Avenue
Stafford Springs, CT. 06076
(203) 684-2766

Reportedly, the dam was built around 1852 by a Converse Mill and acquired by the Warren Woolen Company in the 1880's. This company has now become the Warren Corporation.

f. Operator - Mr. Bud Warrington (203) 684-2766

g. Purpose of Dam - The dam is used to supply process water to the textile mill downstream.

h. Design and Construction History - The following information is believed to be accurate, based on the available data and correspondence. The dam was originally constructed around 1852 by the Converse Mill of Stafford Springs. There is no record of any changes to the dam until 1956, when the spillway apron was reconstructed, riprap was placed on the upstream slopes and the left spillway training wall was repaired. In 1979, the riprap at the right end of the dam was dumped in place.

i. Normal Operational Procedures - Due to vandalism at the dam, the owner is not able to maintain sluice gates at the head of the canal. These gates are, however, kept at the Warren Corporation mill. Therefore, the flow of water to the mill is controlled solely by use of the gates at the downstream end of the canal. The pond level is normally maintained at the spillway crest and a steady flow of water through the canal to the mill is maintained, except for an annual draining of the canal, which is done each July.

1.3 PERTINENT DATA

a. Drainage Area - The drainage area is 16.0 square miles of relatively undeveloped, wooded, rolling terrain. There are five impoundments in the watershed upstream of Warren Pond. Starting from the upper reaches of the watershed, these are New City Pond; Staffordville Reservoir; an unnamed pond at Hydeville; Riverside Pond; and Glenville Pond, all within the Town of Stafford.

b. Discharge at Damsite - Discharge at the project is over the spillway and through the sluice gate openings to the canal.

1. Outlet works (Conduits):	350 cfs (with US water level at top of dam)
two ±3' x ±5.5' sluices to 6' arch culvert	
2. Maximum flood @ damsite:	Not known
3. Ungated spillway capacity @ top of dam el. 519.0:	1,900 cfs

4. Ungated spillway capacity @ test flood el. 523.7:	7,700 cfs
5. Gated spillway capacity @ normal pool:	N/A
6. Gated spillway capacity @ test flood:	N/A
7. Total spillway capacity @ test flood el. 523.7:	7,700 cfs
8. Total project discharge @ top of dam el. 519.9:	2,250 cfs
9. Total project discharge @ test flood el. 523.7:	12,000 cfs

c. Elevations (National Geodetic Vertical Datum based on assumed spillway crest elevation of 516.0 taken from Stafford Springs USGS Quadrangle Map, 1970)

1. Streambed at toe of Dam:	497.0±
2. Bottom of cutoff:	N/A
3. Maximum tailwater:	Not known
4. Normal pool:	516.0±
5. Full flood control pool:	N/A
6. Spillway crest (ungated):	516.0 (assumed datum)
7. Design surcharge (original design):	Not known
8. Top of dam:	519.0±
9. Test flood surcharge:	523.7

d. Reservoir Length

1. Normal pool:	±2,400 ft.
2. Flood control pool:	N/A
3. Spillway crest pool:	±2,400 ft.
4. Top of dam pool:	±2,700 ft.
5. Test flood pool:	±3,100 ft.

e. Reservoir Storage

1. Normal pool:	±105 acre-ft.

2. Flood control pool:	N/A
3. Spillway crest pool:	± 105 acre-ft.
4. Top of dam pool:	±135 acre-ft.
5. Test flood pool:	±175 acre-ft.

f. Reservoir Surface

1. Normal pool:	9 acres
2. Flood control pool:	N/A
3. Spillway crest pool:	9 acres
4. Top of dam pool:	12 acres
5. Test flood pool:	±14 acres

g. Dam

1. Type:	Masonry faced embankment
2. Length:	±293 ft. total ±113 ft. (Spillway) ±180 ft. (Embankments)
3. Height:	22 ft.
4. Top width:	±10 ft.
5. Side slopes:	3H to 1V Upstream 6V to 1H Batter on downstream masonry face
6. Zoning:	N/A
7. Impervious Core:	N/A
8. Cutoff:	N/A
9. Grout curtain:	N/A
10. Other:	N/A

h. Diversion and Regulating Tunnel - N/A

i. Spillway

1. Type:	Broad crested masonry

2. Length of weir:	±113 ft.
3. Crest elevation:	516.0
4. Gates:	N/A
5. Upstream Channel:	Shallow, gravelly
6. Downstream Channel:	Concrete splash apron, boulders for energy dissipation
7. General:	N/A

j. Regulating Outlets

Sluices to culvert and canal

1. Invert:	511.0±
2. Size:	Two ±3'x5.5'
3. Description:	Masonry sluices
4. Control Mechanism:	None in place
5. Other:	Gates kept at mill-installed annually to drain canal

SECTION 2: ENGINEERING DATA

2.1 DESIGN DATA

The available data consists of inventory data by the State of Connecticut, correspondence concerning the 1956 repairs to the dam, and a 1972 inspection report on the dam (See Appendix B).

The available data and correspondence indicate the design features stated previously in this report.

2.2 CONSTRUCTION DATA

The 1956 repairs to the dam were approved, inspected and documented by the State of Connecticut Board for the Supervision of Dams (See pages B-4 to B-6).

2.3 OPERATIONS DATA

No formal operations records are known to exist.

2.4 EVALUATION OF DATA

a. Availability - Existing data was provided by the State of Connecticut, and Buck & Buck, Engineers. The owner made the project available for visual inspection.

b. Adequacy - The limited amount of detailed engineering data available is inadequate to perform an in-depth assessment of the dam, therefore, the assessment of this dam must be based primarily on visual inspection, performance history, hydraulic computations of spillway capacity and hydrologic estimates.

c. Validity - A comparison of record data and visual observations reveals no significant discrepancies in the record data.

SECTION 3: VISUAL INSPECTION

3.1 FINDINGS

a. General - The general condition of the project is fair. The inspection revealed several areas requiring maintenance and monitoring. At the time of the inspection, the pond level was at elevation 516.4, i.e. 2.6 feet below the crest of the dam with water flowing over the masonry spillway.

b. Dam

Top of Dam - The grass covered top of the dam is irregular and gradually sloping to the spillway walls from both abutments (Photos 1 and 2).

Upstream Slope - The upstream slope riprap, held in place by mortar, is slightly eroded and the mortar is cracked in places (Photo 6). Brush and saplings on the slope were noted on the left embankment.

Downstream Face - The masonry downstream face of the dam is mortared on the right embankment, but not on the left. Deteriorated masonry was observed on the downstream face of both embankment sections at a distance of 2 to 4 feet from the edges of the spillway. At these areas the mortar between the blocks is weathered and washed out. Water was observed to be flowing through the joints of the left masonry face at a rate of approximately 6 to 10 gallons per minute (Photo 4). A tree stump, 4 inches in diameter, was noted at the left section near the top of the dam causing a masonry block to be uplifted at this area (Photo 2). Some grass growing from the masonry joints was observed. The toe of the dam is a very heavily wooded area with brush and trees just behind the downstream face (Photo 5).

Spillway - The masonry spillway crest is in good condition. No substantial obstructions of the approach channel or crest were observed (Photos 1 and 2). The training walls adjacent to the spillway crest were cracked, with joint openings between blocks of up to 2 inches. The concrete apron at the toe of the spillway could not be observed, due to the amount of water flowing onto it from over the spillway. The energy dissipation boulders on the apron were sparse towards the right side of the channel and, consequently, there is extensive erosion and uprooted trees along the right side of the downstream channel (Photos 2 and 5).

c. Appurtenant Structures - The masonry culvert through the right embankment section of the dam and the outlet canal are both in poor condition (Photos 1 and 3). There is no gate hoisting mechanism on the upstream headwall of the culvert. Fallen masonry blocks at the right corner of the upstream headwall of the culvert were observed, leaving exposed and eroded earthfill. The left masonry wall of the outlet canal, with concrete coping on the top, was deteriorated with numerous cracks in the concrete and opened, weathered masonry joints. There is a 12 inch cast iron drain pipe

through the masonry canal wall; however, no gate operating mechanism is in place. Water was flowing at the rate of 4 to 6 gpm from the outlet of the drain, which is obstructed by various kinds of debris.

d. Reservoir Area - The area surrounding the pond is generally wooded and undeveloped. There is a bituminous road along the right bank of the pond.

e. Downstream Channel - The downstream channel is the natural streambed of Furnace Brook. It is steep-sided and wooded to the initial impact area.

3.2 EVALUATION

Based upon the visual inspection, the project is assessed as being in fair condition. The following features which could influence the future condition and/or stability of the project were identified.

1. The masonry on the downstream face of the embankment sections adjacent to the spillway can further deteriorate, with seepage increasing through the masonry.

2. Water can collect in the large cracks of the spillway training walls, leading to damage by freeze-thaw cycles.

3. The extensive erosion along the right side of the spillway channel could worsen, causing ponding of water at the toe of the spillway rather than directing spillway discharge to the downstream channel.

4. Blocks from the damaged masonry of the upstream and downstream headwalls of the culvert could fall, causing difficulties with the operation of the canal.

SECTION 4: OPERATIONAL AND MAINTENANCE PROCEDURES

4.1 OPERATIONAL PROCEDURES

a. General - Lake level readings are not taken, but the pond level is normally maintained at or about the elevation of the spillway crest.

b. Description of Any Warning System in Effect - No formal warning system is in effect.

4.2 MAINTENANCE PROCEDURES

a. General - The owner performs regular maintenance of the dam, including cutting the grass and brush on the dam. The owner also performs periodic informal inspections of the dam.

b. Operating Facilities - Due to vandalism at the dam, the gates for the canal intake are kept at the Warren Corporation mill and only installed each July, when the canal is flushed out.

4.3 EVALUATION

The operation and maintenance procedures are generally fair. A formal program of operations and maintenance procedures should be implemented, including documentation to provide complete records for future reference. Also, a formal warning system should be developed and implemented within the time frame indicated in Section 7.1c. Remedial operation and maintenance recommendations are presented in Section 7.3.

SECTION 5: EVALUATION OF HYDRAULIC/HYDROLOGIC FEATURES

5.1 GENERAL

The watershed is 16 square miles of undeveloped, flat to rolling, wooded terrain. Warren Pond is downstream of a series of relatively small ponds and the Staffordville Reservoir which has a watershed of 8.34 square miles.

Warren Pond Dam is a masonry gravity structure, which includes a masonry spillway and adjacent earth and masonry embankments. The dam is basically a low surcharge storage - high spillage project presently used for industrial purposes. The available surcharge storage is too small to have any impact on either the Probable Maximum Flood (PMF) of 24,000 cubic feet per second (cfs) or the ½ PMF of 12,000 cfs.

5.2 DESIGN DATA

No computations could be found for the original design of the dam.

5.3 EXPERIENCE DATA

Extensive repairs were required in 1956, possibly due to damages incurred by the floods of 1955.

5.4 VISUAL OBSERVATIONS

No unusual hydrologic features of the project were observed.

5.5 TEST FLOOD ANALYSIS

Based upon the Army Corps of Engineers' "Preliminary Guidance for Estimating Maximum Probable Discharges", dated March 1978, the watershed classification (rolling), and a watershed area of 16 square miles, a PMF of 24,000 cfs, or 1,500 cfs per square mile, is estimated at the dam site. The range of test floods to be considered for this high hazard, small size dam is from 1/2 to full PMF. Based on the degree of hazard associated with a breach of the dam, the test flood for Warren Pond Dam is equivalent to the 1/2 PMF. Assuming the pond level at the spillway crest at the beginning of the test flood, peak inflow is 12,000 cfs; due to the minimal surcharge storage (Appendix D-5), peak outflow is also 12,000 cfs; and the dam is overtopped by 4.7 feet (Appendix D-2 and D-4). Based on hydraulics computations, the spillway capacity to the top of the dam is 1,900 cfs, which is equivalent to 16% of the routed test flood outflow.

5.6 DAM FAILURE ANALYSIS

The dam failure analysis is based on the April, 1978 Army Corps of Engineers "Rule of Thumb Guidance for Estimating Downstream Dam Failure Hydrographs". Peak outflow before failure of the dam would be about 1,900 cfs and the peak failure outflow from the dam breaching would total about 18,000 cfs. A breach of the dam, with the pond level at the top of the dam, would result in a rise in the water level of the stream at the initial impact area, from a depth of about 2.5 feet just before the breach to a depth of about 13 feet shortly after the breach. This rapid, 10.5 foot increase in water level at the initial impact area would inundate some 10 or more buildings from 5 to 9.5 feet, causing severe economic loss and the loss of more than a few lives. Based on the dam failure analysis, Warren Pond Dam is classified as a high hazard dam.

SECTION 6: EVALUATION OF STRUCTURAL STABILITY

6.1 VISUAL OBSERVATIONS

The visual inspection did not reveal any indications of immediate stability problems. There are areas of seepage, deterioration, and erosion, as described in Section 3, however they are not considered stability concerns at the present time.

6.2 DESIGN AND CONSTRUCTION DATA

The drawings and data available and listed in Appendix B were not sufficient to perform an in depth stability analysis of the dam. No engineering assumptions, data or calculations could be found for the original design of the dam.

6.3 POST CONSTRUCTION CHANGES

Post-construction changes of the project consisted of repairs to the spillway apron, placement of riprap, and repair of the left spillway training wall, all of which would help to enhance the structural stability of the project.

6.4 SEISMIC STABILITY

The project is in Seismic Zone 1 and according to the Recommended Guidelines, need not be evaluated for seismic stability.

SECTION 7: ASSESSMENT, RECOMMENDATIONS AND REMEDIAL MEASURES

7.1 PROJECT ASSESSMENT

a. Condition - Based upon the visual inspection of the site and past performance, the project is in fair condition, with areas which require maintenance, repair and monitoring.

Based upon the Army Corps of Engineers' "Preliminary Guidance for Estimating Maximum Probable Discharges" dated March, 1978, and hydraulic/hydrologic computations, the peak inflow to the pond at test flood is 8610 cubic feet per second (cfs). Peak outflow is 7730 cfs with the dam overtopped 2.7 feet and water to elevation 86.2. Based upon hydraulic computations, the spillway capacity with the pond level to the top of the dam is 1610 cfs, which is equivalent to approximately 21% of the routed test flood outflow.

b. Adequacy of Information - The information avaialble is such that an assessment of the condition and stability of the project must be based solely on visual inspection, past performance and sound engineering judgement.

c. Urgency - It is recommended that the measures presented in Section 7.2 and 7.3 be implemented within 1 (one) year of the owner's receipt of this report.

7.2 RECOMMENDATIONS

It is recommended that further studies be made by a registered professional engineer qualified in dam design and inspection pertaining to the following items: Recommendations made by the engineer should be implemented by the owner.

1. A detailed hydraulic/hydrologic analysis of the adequacy of the existing project discharge and existing outlet facilities.

2. An inspection of the low-level outlet through the dam to evaluate the leaks through the top and sides of the masonry culvert.

3. Restoration of the sluice gate and hoisting mechanism for the low-level outlet.

4. Removal of trees of 4 inches and greater in diameter from the dam and spillway. This should include the removal of root systems and proper backfilling.

5. Evaluation of the condition of the masonry of the dam and spillway and spillway discharge channel when no water is flowing through the high-level outlet or over the spillway. This should include examination into the extent of possible erosion at the toe and at the high-level outlet and evaluation of any undermining, seepage or deterioration on the masonry downstream face.

4. Removal of trees within 15 feet from the toe of the dam, including removal of root systems and proper backfilling of the resultant cavities.

7.3 REMEDIAL MEASURES

a. Operation and Maintenance Procedures - The following measures should be undertaken by the owner within the length of time indicated in Section 7.1.c, and continued on a regular basis:

1. Round-the-clock surveillance should be provided during periods of heavy precipitation or high project discharge. A formal downstream warning system should be developed, to be used in case of emergencies at the dam.

2. A formal program of operation and maintenance procedures should be instituted and fully documented to provide accurate records for future reference.

3. A comprehensive program of inspection by a registered professional engineer qualified in dam inspection should be instituted on an annual basis.

4. Deteriorated masonry of the downstream face of the embankments adjacent to the spillway should be repaired.

5. Cracks in the masonry of the spillway training walls adjacent to the spillway crest and in the mortared riprap of the upstream slope of the right dam section should be sealed.

6. The cracked and damaged masonry of the culvert upstream headwall and canal training wall should be reinforced.

7. Additional boulders for energy dissipation should be placed at the right side of the spillway apron and other suitable measures should be undertaken to prevent erosion of the spillway downstream channel bank.

8. A plug should be installed in the inlet of the 12 inch C.I. drain pipe through the canal dike to stop the flow of water.

9. Removal of stumps and cutting of grass, brush and trees on the crest, slopes and within 10 feet of the toe of the dam should be continued as part of the routine maintenance procedures at the dam.

7.4 ALTERNATIVES

This study has identified no practical alternatives to the above recommendations.

APPENDIX A

INSPECTION CHECKLIST

VISUAL INSPECTION CHECK LIST

PARTY ORGANIZATION

PROJECT Warren Pond Dam DATE: March 24, 1980

TIME: 1:30 - 3:30 PM

WEATHER: Cloudy, 45°

W.S. ELEV. 516.4 U.S. 497± DN.S

PARTY:	INITIALS:	DISCIPLINE:
1. Peter Heynen	PH	Geotechnical
2. Miron Petrovsky	MP	Geotechnical
3. Theodore Stevens	TS	Geotechnical
4. Hector Moreno	HM	Hydraulics
5. Robert Jahn	RJ	Hydraulics
6. William Sorensen	WS	Owner

	PROJECT FEATURE	INSPECTED BY	REMARKS
1.	Right & Left Embankments	All	
2.	Culvert Upstream Headwall	All	
3.	Downstream Headwall & Canal Wall	All	
4.	Spillway	All	
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			

PERIODIC INSPECTION CHECK LIST

PROJECT Warren Pond Dam DATE 3-24-80

PROJECT FEATURE Right & Left Earth Embankments BY PH, MP, TS, HM, RJ

AREA EVALUATED	CONDITION
DAM EMBANKMENT	
Crest Elevation	Varies 519.0 to 521.5
Current Pool Elevation	516.4
Maximum Impoundment to Date	Not known
Surface Cracks	Cracking of US mortared riprap
Pavement Condition	N/A
Movement or Settlement of Crest	None observed
Lateral Movement	
Vertical Alignment	Appears good
Horizontal Alignment	
Condition at Abutment and at Concrete Structures	Fair
Indications of Movement of Structural Items on Slopes	None observed
Trespassing on Slopes	Yes - also campfire remnants on crest
Sloughing or Erosion of Slopes or Abutments	Some - minor
Rock Slope Protection-Riprap Failures	Minor
Unusual Movement or Cracking at or Near Toes	None observed
Unusual Embankment or Downstream Seepage	No
Piping or Boils	No
Foundation Drainage Features	N/A
Toe Drains	N/A
Instrumentation System	N/A

PERIODIC INSPECTION CHECK LIST

PROJECT _____ DATE 3-24-80

PROJECT FEATURE Culvert Upstream Headwall BY PH, MP, TS, HM, RS

AREA EVALUATED		CONDITION
OUTLET WORKS-INTAKE CHANNEL AND INTAKE STRUCTURE		
a) Approach Channel		
Slope Conditions		Could not observe
Bottom Conditions		
Rock Slides or Falls		Some blockage by rocks
Log Boom		None
Debris		None observed
Condition of ~~Concrete~~ Masonry Lining		Fair - Some deterioration
Drains or Weep Holes		None observed
b) Intake Structure		
Condition of ~~Concrete~~ Masonry		Fair - Some deterioration
Stop Logs and Slots		None in place - kept at mill downstream

PERIODIC INSPECTION CHECK LIST

PROJECT Warren Pond Dam DATE 3-24-80

PROJECT FEATURE Downstream Headwall & Channel Wall BY FH, MP, TS, HM, RS

AREA EVALUATED		CONDITION
OUTLET WORKS-OUTLET STRUCTURE AND OUTLET CHANNEL		
General Condition of ~~Concrete~~ Masonry		Fair - Some deterioration
Rust or Staining		None observed
Spalling		
Erosion or Cavitation		
Visible Reinforcing		
Any Seepage or Efflorescence		
Condition at Joints		Fair
Drain Holes		None observed
Channel		
Loose Rock or Trees Overhanging Channel		Some - minor
Condition of Discharge Channel		Fair

PERIODIC INSPECTION CHECK LIST

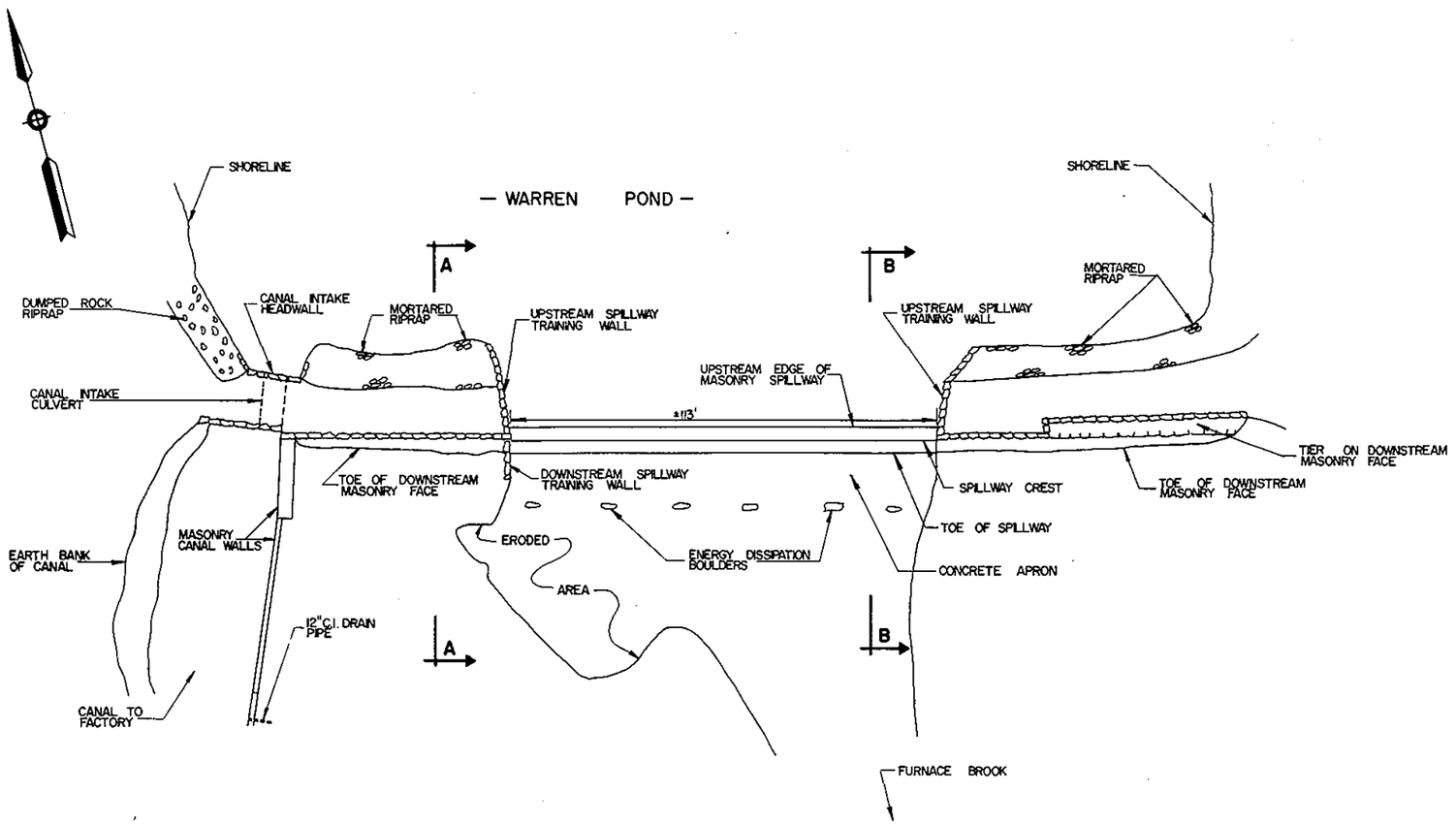
PROJECT Warren Pond Dam DATE 3-24-80

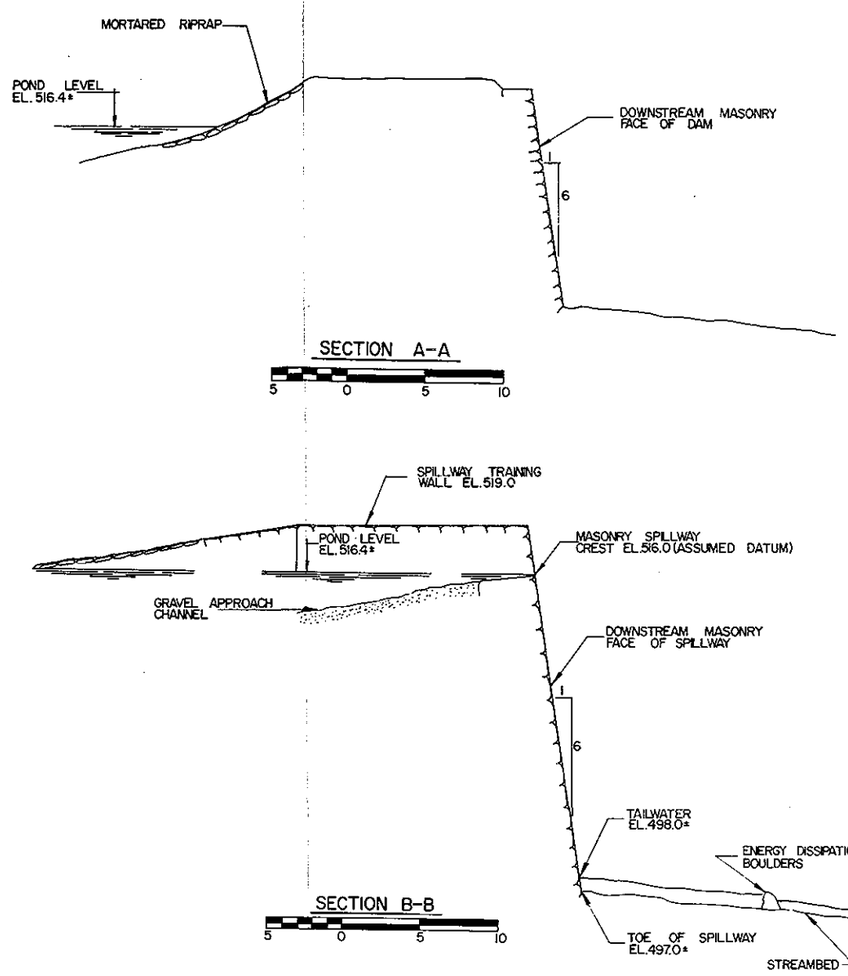
PROJECT FEATURE Spillway BY PH, MP, TS, HM, RS

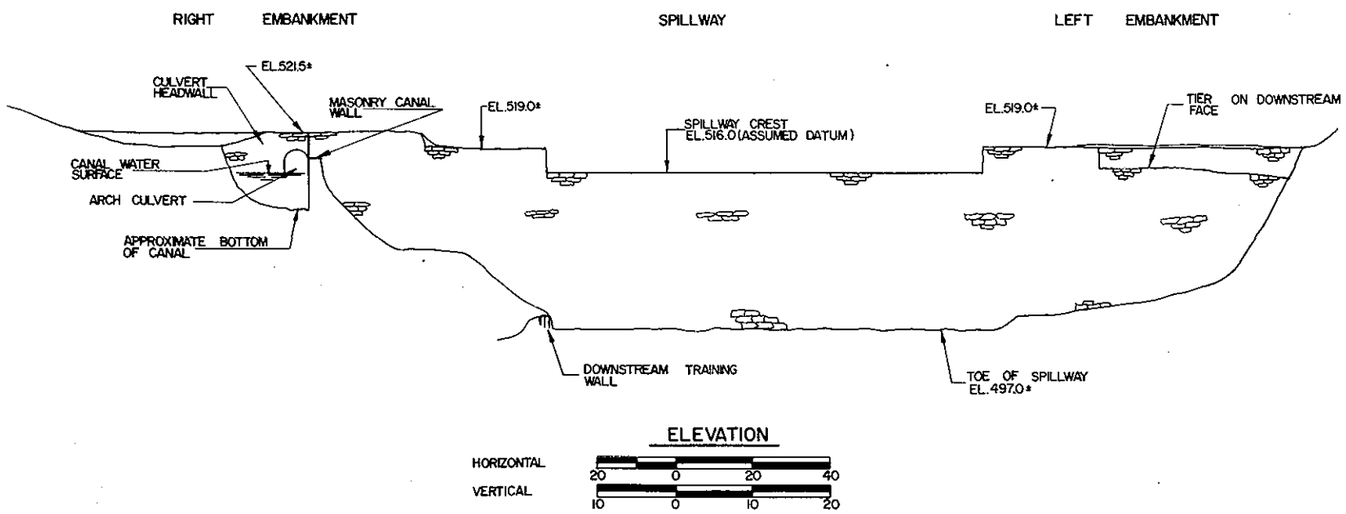
AREA EVALUATED	CONDITION
OUTLET WORKS-SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS	
a) Approach Channel	
General Condition	Good
Loose Rock Overhanging Channel	No
Trees Overhanging Channel	No
Floor of Approach Channel	Shallow, gravel
b) Weir and Training Walls	
General Condition of ~~Concrete~~ Masonry	Fair-some deterioration
Rust or Staining	None observed
Spalling	
Any Visible Reinforcing	
Any Seepage or Efflorescence	
Drain Holes	
c) Discharge Channel	
General Condition	Fair - Erosion of right bank
Loose Rock Overhanging Channel	No
Trees Overhanging Channel	Some - minor
Floor of Channel	Concrete apron, energy dissipation boulders, natural stream bed
Other Obstructions	

APPENDIX B

ENGINEERING DATA AND CORRESPONDENCE







NOTES

1. THIS PLAN WAS COMPILED FROM A CAHN ENGINEERS INSPECTION OF THE DAM DATED MARCH 19, 1980. DIMENSIONS SHOWN ARE APPROXIMATE. NOT ALL TOPOGRAPHIC AND/OR STRUCTURAL . FEATURES ARE NECESSARILY IDENTIFIED.
2. NO ELEVATIONS WERE AVAILABLE FOR THE DAM, THEREFORE THE WATER SURFACE ELEVATION OF 516.0 FOR THE POND SHOWN ON THE U.S.G.S STAFFORD SPRINGS QUADRANGLE MAP WAS ASSUMED TO BE THE ELEVATION OF THE SPILLWAY CREST. ALL OTHER ELEVATIONS SHOWN ARE REFERENCED TO THE ASSUMED SPILLWAY CREST ELEVATION.
3. WATER SURFACE ELEVATIONS, SHORELINE AND TAILWATER CONFIGURATIONS ARE APPROXIMATE, AS OBTAINED DURING THE DAM INSPECTION ON MARCH 19, 1980.

CAHN ENGINEERS INC. WALLINGFORD, CONNECTICUT ENGINEER	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS
PLAN ELEVATION & SECTIONS

WARREN POND DAM

FURNACE BROOK STAFFORD, CONNECTICUT

DRAWN BY	CHECKED BY	APPROVED BY	SCALE: AS NOTED	
M. Hartman	TJS		DATE: MAY 1980	SHEET B-1

SUMMARY OF DATA AND CORRESPONDENCE

indi Brook

B

1D 16
CT-335
RAM
24

STATE BOARD FOR THE SUPERVISION OF DAMS
INVENTORY DATA

NAME OF DAM OR POND [illegible] Pond

CODE NO. W24.0 FU0.6

LOCATION OF STRUCTURE:

Town [illegible]

Name of Stream [illegible]

U.S.G.S. Quad. [illegible] Long. 72-18.0 Lat. 41-57.6

OWNER: Warren Woolen Co.
Furnace Avenue
Stafford Springs, CT
684-2766 ck 12/78

Pond Used For: RECREATION DA = 16.0

Dimensions of Pond: Width ____ Length ____ Area 10.1

Depth of Water below Spillway Level (Downstream) 20' [illegible]

Total Length of Dam 260' Length of Spillway 100'

Height of Abutments above Spillway 3'

Type of Spillway Construction [illegible]

Type of Dike Construction [illegible]

Downstream Conditions [illegible]

Summary of File Data [illegible]

Remarks [illegible]

1880?

B-2

Warren Mill

THE WARREN WOOLEN CO.

FINE WOOLENS & SPECIALTY FABRICS

Warren Springs Conn.

September 14, 1955

Mr. Henry W. Buck
650 Main Street
Hartford 3, Conn.

Dear Henry:

We were able to draw the pond down and inspect the dam and apron today. Water still covered the bottom of the lower apron, but by prodding with a long pole we believe there are spots where the apron has been undercut back four or five feet and a depth generally less than twelve inches. Joe Mottes (you will remember him as contractor on our toilet stack) proposes to bulldoze the stones back to within three or four feet of the edge of the apron and, then, using the pile of stones as more or less of a form, pour in concrete, throw in big stones, and prod the concrete into the undercut.

The stone abutment on the far side of the dam opening is not in as good shape as the one on the near side, and Joe has suggested that, in addition to pointing, it would be well to dig out a foot or two on the earth side and fill with concrete. The purpose would be to help hold the stones in position plus presenting a smoother surface for action of the earth in freezing and thawing.

You will recall that on the far side of the dam the outer tier of stone has not come up to the top of the dam. You suggested that we throw some stones in any low spots in this area. Joe has suggested that he cap this tier of stones with concrete and give it a pitch.

In building a rip rap on the pond side of the shoulders, Joe proposes to simply dump truckloads of large stones---many will be much more than one-hundred pounds---along this area.

The remainder of your recommendations, such as, filling all washed-out areas with gravel, adding loam, etc., will be carried out, but we would appreciate your advice on the items listed above.

If you feel you would like to have another "look see" at the apron, let us know, and we will make sure that the water is down.

Very truly yours,
THE WARREN WOOLEN CO.

wls/el

570 WOLCOTT HILL ROAD
WETHERSFIELD, CONNECTICUT

A-153-75

SEPTEMBER 16, 1955

THE WARREN WOOLEN COMPANY
STAFFORD SPRINGS, CONNECTICUT

GENTLEMEN:

REPLYING TO YOUR LETTER OF SEPTEMBER 14TH REGARDING THE REPAIRS TO YOUR DAM, I FEEL THAT ALL THE SUGGESTIONS MADE BY THE CONTRACTOR ARE EXCELLENT. THE CAP HE IS PROPOSING ON THE LOWER TIER OF STONES IN THE EAST ABUTMENT I DO NOT FEEL IS ESSENTIAL TO THE STABILITY OF THE DAM. HOWEVER, BY SHEDDING WATER IN THIS AREA IT WILL CERTAINLY REDUCE POSSIBLE MAINTENANCE OF THAT SECTION OF THE STONE WORK.

I AM ENCLOSING CONSTRUCTION PERMIT No. 5-47 COVERING THIS WORK AND WOULD ASK THAT I BE NOTIFIED WHEN THE WORK IS COMPLETED SO THAT I MAY INSPECT IT AND ISSUE THE REQUISITE CERTIFICATE OF APPROVAL IF THE WORK IS FOUND IN SATISFACTORY CONDITION.

IF DURING THE COURSE OF THE REPAIRS, SITUATIONS DEVELOP ON WHICH YOU FEEL YOU WOULD LIKE TO HAVE ME INSPECT THE WORK OR CONSULT WITH THE CONTRACTOR, IF YOU WILL LET ME KNOW I WILL BE VERY GLAD TO VISIT THE WORK.

SINCERELY YOURS,

STATE BOARD OF SUPERVISION OF DAMS

HENRY WOLCOTT BUCK

STATE OF CONNECTICUT

BOARD OF SUPERVISION OF DAMS 5- 47

PRELIMINARY PERMIT

WETHERSFIELD, Conn.

SEPTEMBER 16, 1955

To Owner THE WARREN WOOLEN COMPANY

P. O. Address STAFFORD SPRINGS, CONN.

I have inspected the site and have examined the plans marked .....

.....

and the specifications therefore, submitted by you to the Board of Supervision of Dams for REPAIR OF DAM

.....

on FURNACE BROOK in the Town of STAFFORD

The same are approved, and such proposed construction work is hereby authorized.

Henry Wolcott Buck
Member, Board of Supervision of Dams

THIS PERMIT WILL BE VOID IF WORK IS NOT STARTED PRIOR TO APRIL 15, 1956

6 HWB DICK RUGIN. THEY ARE NOT AT ALL SATISFIED WITH THE WAY THE RIP RAP IS GOING ON UPSTREAM FACE OF THE DYKE AT EITHER END OF THEIR DAM. AFTER DISCUSSION HE FELT THAT HE WOULD PREFER TO HAVE ME COME OUT RATHER THAN TURN IT OVER TO WHOEVER IS TAKING MY PLACE ON THE DAMS BOARD. ARRANGED A DATE TO VISIT THE WORK AND GO OVER IT WITH HIM.

6 HWB JOB INSPECTION WITH DICK RUGIN, HIS MASTER MECHANIC, VALENTINE, JOE MOTTES AND TWO MEN WORKING FOR JOE ON THE WORK. THE RIP RAP IS TO BE FINISHED WITH STONES NOT LESS THAN 150 LBS., LAID TO A LINE ALONG THE TOP. THIS LINE MUST BE DEAD LEVEL FOR THE EXTENT OF BOTH DYKES UP TO THE POINT WHERE THEY RISE ABRUPTLY. THE RIP RAP ON THE WEST SIDE IS TO BE PARTIALLY REMOVED WHERE THE STONES ARE TOO SMALL AND AT THE EDGE OF THE SPILLWAY IS TO BE EXTENDED FURTHER OUT INTO THE POND TO GET AT LEAST ONE FOOT BELOW MEAN LOW WATER. THE ENTIRE FACE OF THE RIP RAP IS THEN TO BE FLUSHED HEAVILY WITH A HEAVY HOSE STREAM TO SETTLE ALL OF THE FILL, IT IS THEN TO BE FLUSHED COMPLETELY WITH A 5-BAG CONCRETE USING THIS TO FILL ALL OF THE CHINKS AND IS TO BE COVERED WITH SOIL AND KEPT WET FOR NOT LESS THAN TWO WEEKS. THE UPSTREAM EDGES OF BOTH ABUTMENTS AT THE MAIN SPILLWAY ARE TO HAVE THE JOINTS CUT OUT AND REPOINTED. ON THE EAST ABUTMENT THE LEDGE AT THE DOWNSTREAM FACE IS TO BE BUILT OUT AND CONCRETED, SLOPING SLIGHTLY DOWN-STREAM. PLUMBS ARE TO BE USED IN THIS. AT THE HIGHER LEVEL OF THE DYKE, THE DOWNSTREAM EDGE IS TO BE FLUSHED WITH CONCRETE AND THEN STONES ARE TO BE SET IN ALL OF THE LOW PLACES TO BRING A STONE EDGING ALONG THE LOWER FACE LEVEL. THERE IS TO BE NOT LESS THAN 6 INCHES OF TOP SOIL SPREAD OVER BOTH DYKES, ABSO-LUTELY LEVEL AT THE STONE AT THE DOWNSTREAM FACE AND PITCHING SLIGHTLY TOWARD THE POND. THIS IS TO BE SEEDED WITH AT LEAST 50% OF PERENNIAL RYE, THE BALANCE FESCUE AND RED TOP AS THEY FEEL BEST. EVERYTHING SEEMS TO BE COMPLETELY UNDER CONTROL. THEY WILL CALL IF THEY NEED ANYTHING FURTHER. AUG 31 '56 H.W.B.

5 HWB WITH BILL SORENSEN AND HIS SUPERINTENDENT VISITED THE DAM. JOE MOTTAS HAS DONE AN EXCELLENT JOB ON FIXING THE RIP RAP AS WE ASKED FOR, FILLING IT WITH CONCRETE AND DRESSING THE SURFACE. THERE WERE THREE ITEMS WHICH ARE TO BE TAKEN CARE OF NEXT SPRING. ON THE EASTERLY ~~ABUTMENT~~ DYKE THERE IS ONE AREA THAT IS DOWN ABOUT 6 INCHES. THIS IS TO BE FILLED AND RE-SEEDED. AT THE EXTREME EASTERLY END THE TOP SOIL IS TO BE CARRIED FURTHER UP UNTIL IT REACHES THE HILLSIDE AND IS TO BE SEEDED. AT THE WEST SIDE IMMEDIATELY WEST OF THE SPILLWAY AND AT THE UPSTREAM FACE OF THE DAM, THERE IS A LUMP OF CONCRETED ROCK, PERHAPS 6 FEET IN DIAMETER, WHICH STANDS ABOVE THE GENERAL ELEVATION OF THE REST OF THE DYKE. THIS IS TO BE CUT OFF SO THAT THE WHOLE AREA IS LEVEL AND WILL PASS AN EVEN FLOW OF WATER IN CASE OF AN EXTREME STORM. SAID I WOULD TALK TO JOH MOZZOCHI ABOUT HAVING A PERMIT ISSUED FOR APPROVAL.
OCT 2 '56 R.D.R. OCT 2 '56 H.W.B.

9/56 HWB CALLED JOHN MOZZOCHI. PROPOSED PROCEDURE ENTIRELY SATISFACTORY TO HIM. HE WILL ISSUE CER. OF APPROVAL
OCT 2 '56 R.D.R.

STATE OF CONNECTICUT

STATE BOARD FOR THE SUPERVISION OF DAMS

STATE OFFICE BUILDING · HARTFORD 15, CONNECTICUT

D

October 26, 1956

The Warren Woolen Company
Stafford Springs, Connecticut

File - No. A-153-75

Gentlemen:

Henry W. Buck, former member of this Board, advises that he has made a final inspection of the repairs on your dam and has approved the work.

I am enclosing herewith, certificate of approval covering the work.

Very truly yours,

John J. Mozzochi

John J. Mozzochi
Member State Board of Dams

JJM:hk
enc.
cc: Mr. H. W. Buck
Mr. W. S. Wise

STATE OF CONNECTICUT

BOARD OF SUPERVISION OF DAMS 5- 47

CERTIFICATE OF APPROVAL

Glastonbury, Conn.

October 26, 1956

To Owner The Warren Woolen Company

P. O. Address Stafford Springs, Conn.

Name of Structure .....

This is to certify that the following construction work: Repair of Dam, performed on property owned by you on Furnace Brook, in the Town of Stafford for which preliminary permit was issued September 15, 1955 has been completed to the satisfaction of this Board and that such structure is approved and has been found to be safe as of date of this certificate.

BOARD OF SUPERVISION OF DAMS
BY John J. Mozzochi, Member

Note: The owner is required by law to record this certificate in the Land Records of the town or towns in which the dam or reservoir is located.

IACCHI & HOFFMAN • ENGINEERS

EXECUTIVE OFFICES • 44 GILLETT STREET • HARTFORD, CONN., 06105 • PHONE (203) 525-6631

J. MACCHI, P.E.
R. HOFFMAN, P.E.
CHAEL GIRARD

SOCIATE CONSULTANT
OF. C. W. DUNHAM

January 24, 1972

State of Connecticut
Department of Environmental Protection
165 Capitol Avenue
Hartford, Connecticut

Attention: Mr. William H. O'Brien, III

Re: Warren Pond Dam
Stafford Springs, Conn.
Code W24.0 FV0.6

Gentlemen:

An inspection of the above-referenced dam was made by William H. O'Brien, Victor Galgowski and A. J. Macchi on Friday, January 21, 1972.

The dam is owned by Stafford Water Power Co., c/o Warren Woolen Co.

This dam is constructed with a slightly battered wall of heavy random masonry stones. It is about 120 feet long by 20 feet high. The spillway is about 100 feet long with about 3 feet of freeboard at each abuttment.

This dam and appurtenant structures were found in good condition and not in need of repair.

Very truly yours,

MACCHI & HOFFMAN, ENGINEERS

A. J. MACCHI

vmc

TERDEPARTMENT MESSAGE
O 201 2-69

SAVE TIME: *Handwritten messages are acceptable. Use carbon if you really need a copy.*

	AGENCY	DATE
File	Water & Related Resources	Jan. 25, 1972

	AGENCY	TELEPHONE
William H. O'Brien, III	Water & Related Resources	

Civil Engineer

JECT
Warren Pond, Stafford (Code No. W24.0FUS.6)

On January 21, the undersigned and John Macchi, consultant, and Vic Galagowski inspected the subject dam.

It was noted that there are some small trees growing on top of the dam and from the face of the dam. The dam otherwise appeared to be in very good condition.

It is recommended that a letter be written to the owner requesting that the trees be removed.

Civil Engineer

:ljg

SAVE [illegible]. If convenient, handwritten reply to [illegible] on this same sheet.

APPENDIX C

DETAIL PHOTOGRAPHS

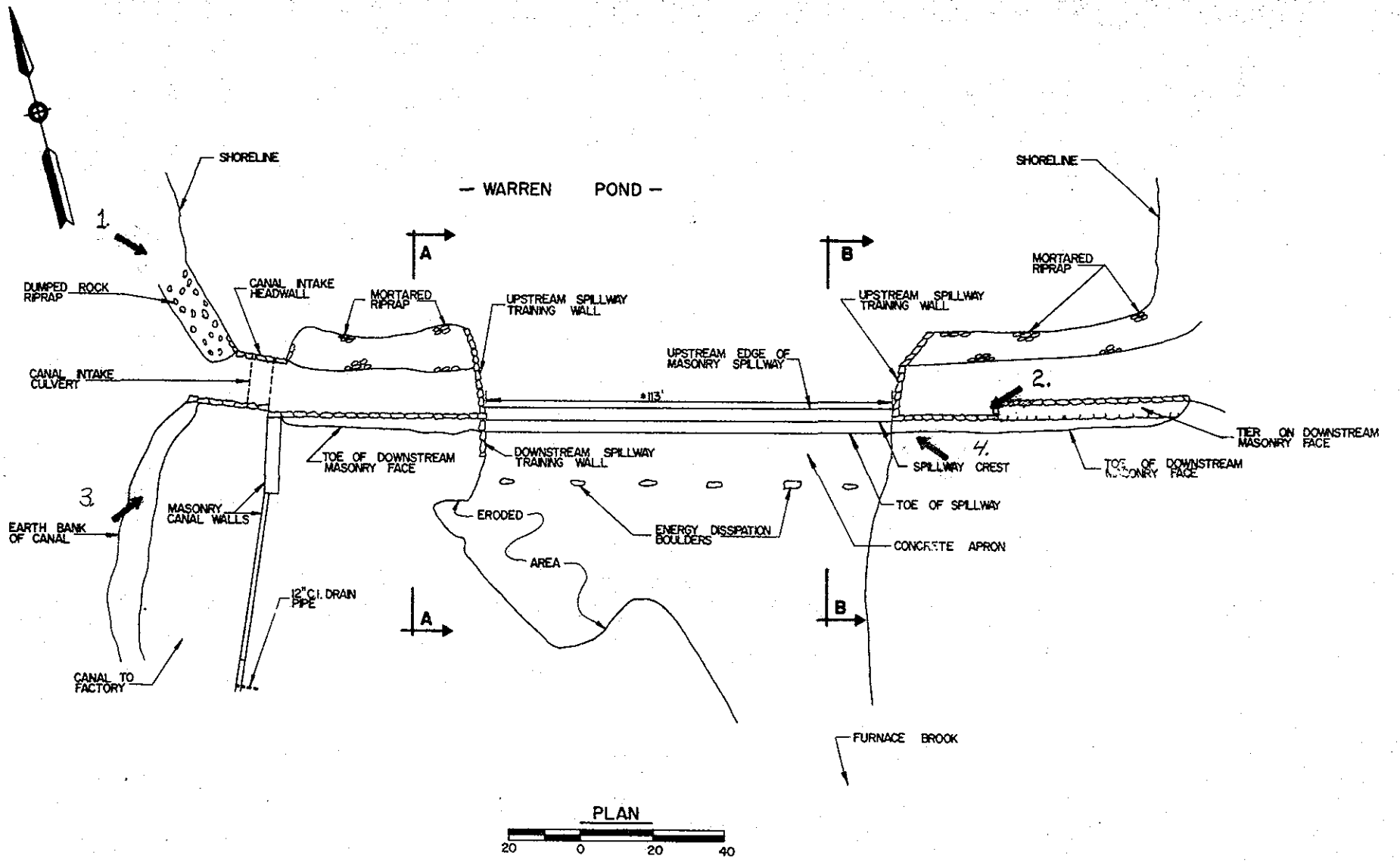


PHOTO LOCATION PLAN

WARREN POND DAM

SHEET C-1

Photo 1 - Upstream slope and top of dam. Upstream headwall of canal intake culvert in foreground (3/24/80).

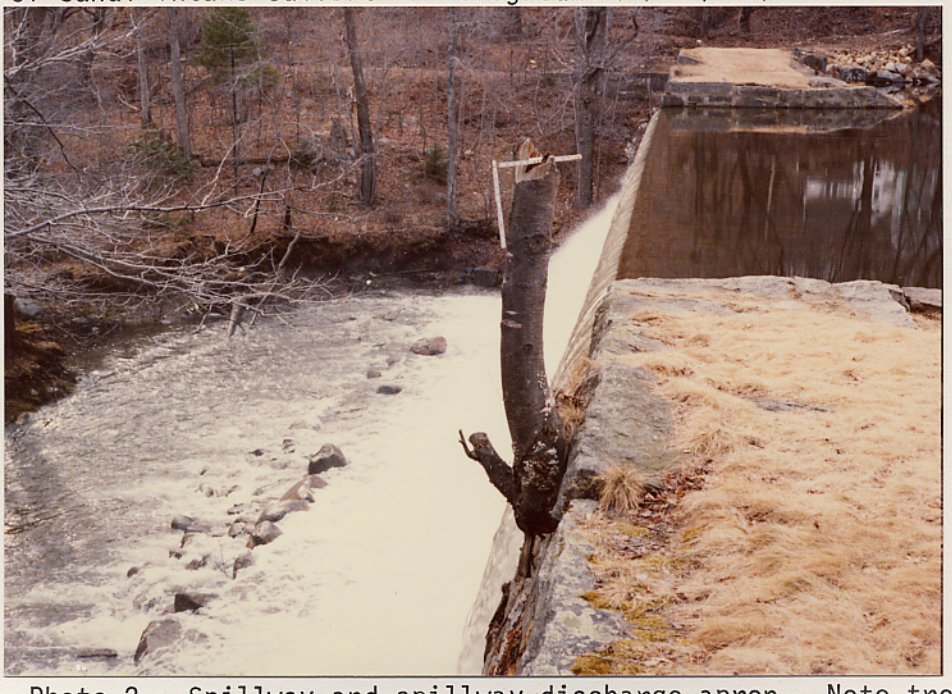


Photo 2 - Spillway and spillway discharge apron. Note tree stump and uplifted masonry block in foreground (3/24/80).

US ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS. CAHN ENGINEERS INC. WALLINGFORD, CONN. ENGINEER	NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS	Warren Pond Dam Furnace Brook Stafford, Conn. CE# 27 785 KA DATE May '80 PAGE C-1

Photo 3 - Downstream headwall of arch culvert and masonry canal wall (3/24/80).

Photo 4 - Seepage from downstream face of left embankment adjacent to spillway (3/24/80).

Photo 5-Downstream face of right embankment. Note trees near toe of embankment and erosion of channel bank (3/24/80).

Photo 6 - Cracked mortar of upstream slope riprap. Note small stump with new growth (3/24/80).

APPENDIX D

HYDRAULICS/HYDROLOGIC COMPUTATIONS

U.S.G.S QUADRANGLES

STAFFORD SPRINGS	1970
WESTFORD	1970
MONSON	1967
WALES	1967

DRAINAGE AREA
16.0 SQ. MI.

WARREN POND DAM

INITIAL IMPACT AREA

APPROXIMATE LIMITS OF DAM FAILURE OUTFLOW

CAHN ENGINEERS INC. WALLINGFORD, CONNECTICUT ENGINEER	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED DAMS

DRAINAGE AREA MAP

WARREN POND DAM

FURNACE BROOK STAFFORD, CONNECTICUT

DRAWN BY.	CHECKED BY	APPROVED BY	SCALE: 1" = 3000'
M.d./mac	TJS		DATE: MAY 1980 SHEET D-1

HYDROLOGIC / HYDRAULIC INSPECTION

WARREN POND DAM, STAFFORD, CT.

I) PERFORMANCE AT PEAK FLOOD CONDITIONS:

1) PROBABLE MAXIMUM FLOOD (PMF)

a) WATERSHED CLASSIFIED AS "ROLLING"

b) WATERSHED AREA:

LOCATED ON FURNACE BROOK D/S FROM A SERIES OF RELATIVELY SMALL PONDS AND THE STAFFORDVILLE RESERVOIR. THE TOTAL WATERSHED IS SUBDIVIDED AS FOLLOWS:*

i) D.A. TO STAFFORDVILLE RESERVOIR: $(DA)_{S.R.} = 8.34^{sq\,mi}$
ii) INCREMENT TO WARREN POND DAM: $\Delta(DA) = 7.66^{sq\,mi}$
iii) TOTAL D.A. TO WARREN POND DAM. $DA = \underline{16.0}^{sq\,mi}$

*NOTE: DRAINAGE AREAS FROM CONN. DEP. BULLETIN N°1, 1972 (GAZETTEER OF NATURAL DRAINAGE AREAS) p. 3.

c) PEAK FLOODS (FROM NED-ACE GUIDELINES - GUIDE CURVES FOR PMF):

i) FROM GUIDE CURVES $CSM = 1550^{CFS/sq\,mi}$ (TOTAL D.A.)

THE PEAK FLOOD REDUCTION AT WARREN FROM STAFFORDVILLE RESERVOIR REGULATION ($A = 160^{AC.}$) IS RELATIVELY SMALL AND THEREFORE, IT WILL BE TAKEN INTO CONSIDERATION BY REDUCING THE CSM TO:

$$(CSM)_{ADJ.} = \underline{1500}^{CFS/sq\,mi}$$

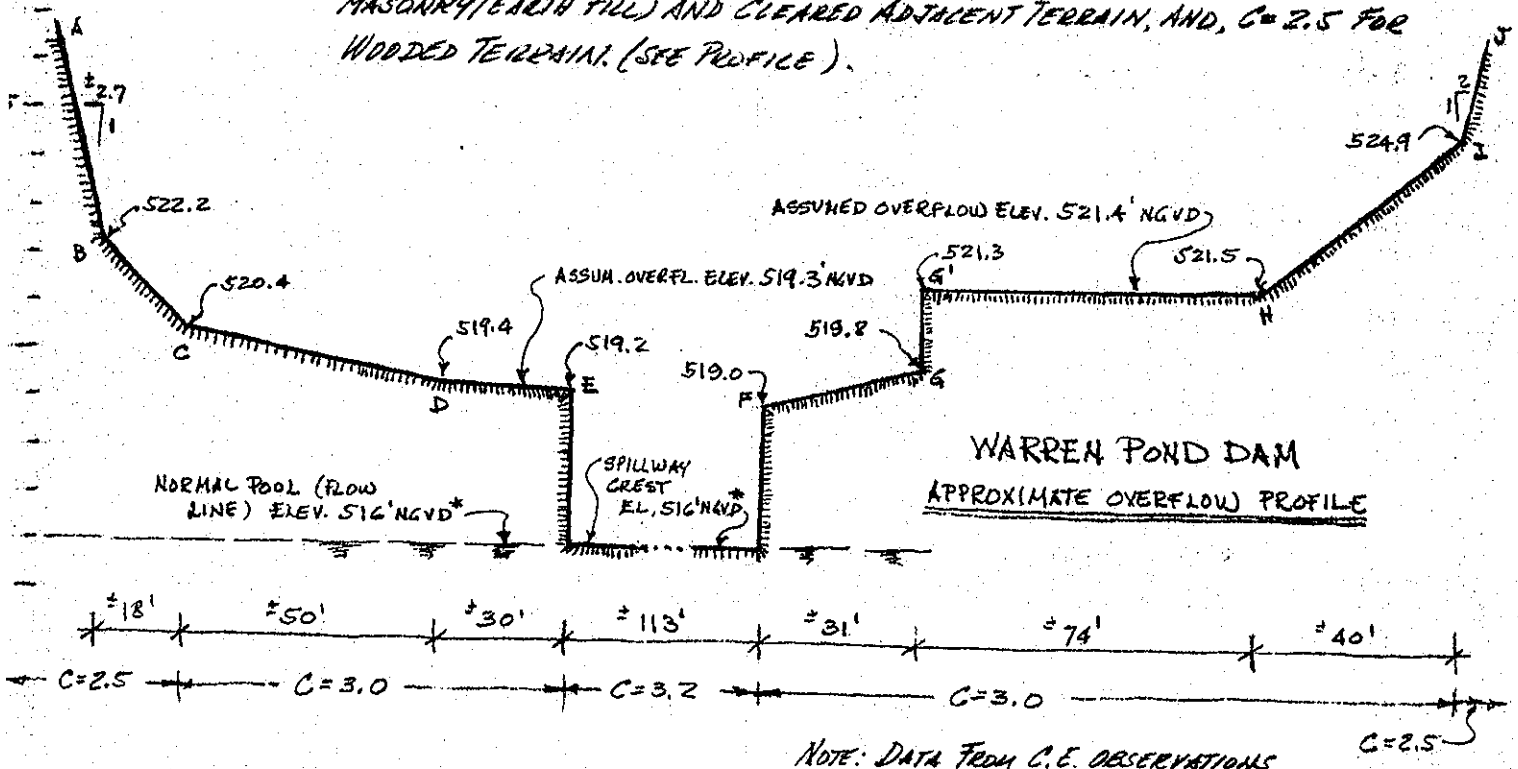
ii) $PMF = 1500 \times 16 = \underline{24000}^{CFS}$
iii) $\frac{1}{2}$ PMF = $\underline{12000}$ CFS

2) SURCHARGE AT PEAK INFLOWS

a) OUTFLOW RATING CURVE

i) SPILLWAY AND OVERFLOW PROFILE FOR SURCHARGES OVERTOPPING THE DAM:

SPILLWAY (±) 113' LONG, BROADCRESTED U/S FACE ON (±) 9"/0 1' SLOPE; VERTICAL D/S FACE, (SEE OVERFLOW PROFILE BELOW) ASSUME C=3.2 FOR THE SPILLWAY FLOW; C=3.0 FOR THE DAM (STONE MASONRY/EARTH FILL) AND CLEARED ADJACENT TERRAIN, AND, C=2.5 FOR WOODED TERRAIN. (SEE PROFILE).



WARREN POND DAM
APPROXIMATE OVERFLOW PROFILE

NOTE: DATA FROM C.E. OBSERVATIONS ON 4/1/80 BY HLL & R.J.

*NOTE: W.S. ELEV. 516' ON THE U.S.G.S. STAFFORD SPRINGS, CT. QUADRANGLE SHEET (REV. 1970) IS ASSUMED TO BE THE SPILLWAY CREST ELEVATION ON NATIONAL GEODETIC VERTICAL DATUM (NGVD)

ii) THEREFORE, ASSUMING EQUIVALENT LENGTHS FOR THE SLOPING TERRAIN, THE OVERFLOW RATING CURVE CAN BE APPROXIMATED AS FOLLOWS (SEE PROFILE p. D-2) - SURCHARGE (H) FROM SPILLWAY CREST:

1') SECTION AB : $Q_{AB} = \frac{2}{3} \times 2.7 \times 2.5 (H-6.2)^{5/2} = \underline{4.5 (H-6.2)^{5/2}}$

2') SECTION BC :

$(Q_{BC})_1 = \frac{2}{3} \times 10 \times 2.5 (H-4.4)^{5/2} = \underline{16.7 (H-4.4)^{5/2}}$ $H \leq 6.2'$

$(Q_{BC})_2 = 2.5 \times 18 \times (H-4.83)^{3/2} = \underline{45 (H-4.83)^{3/2}}$ $H > 6.2'$

3') SECTION CD:

$(Q_{CD})_1 = \frac{2}{3} \times 50 \times 3 (H-3.3)^{5/2} = \underline{100 (H-3.3)^{5/2}}$ $H \leq 4.4'$

$(Q_{CD})_2 = 3 \times 50 (H-3.51)^{3/2} = \underline{150 (H-3.51)^{3/2}}$ $H > 4.4'$

4') SECTION DE:

$Q_{DE} = 3 \times 30 \times (H-3.3)^{3/2} = \underline{90 (H-3.3)^{3/2}}$

5') SPILLWAY (SECTION EF):

$Q_S = Q_{EF} = 3.2 \times 113 \times H^{3/2} = \underline{362 H^{3/2}}$

6') SECTION FG:

$(Q_{FG})_1 = \frac{2}{3} \times 31.8 \times 3 (H-3)^{5/2} = \underline{77.5 (H-3)^{5/2}}$ $H \leq 3.8'$

$(Q_{FG})_2 = 3 \times 31 (H-3.19)^{3/2} = \underline{93 (H-3.19)^{3/2}}$ $H > 3.8'$

7') SECTION GH:

$Q_{GH} = 3 \times 74 \times (H-5.4)^{3/2} = \underline{222 (H-5.4)^{3/2}}$

8') SECTION HI

$(Q_{HI})_1 = \frac{2}{3} \times 40 \times 3 \times (H-5.4)^{5/2} = \underline{23.5 (H-5.4)^{5/2}}$ $H \leq 8.9'$

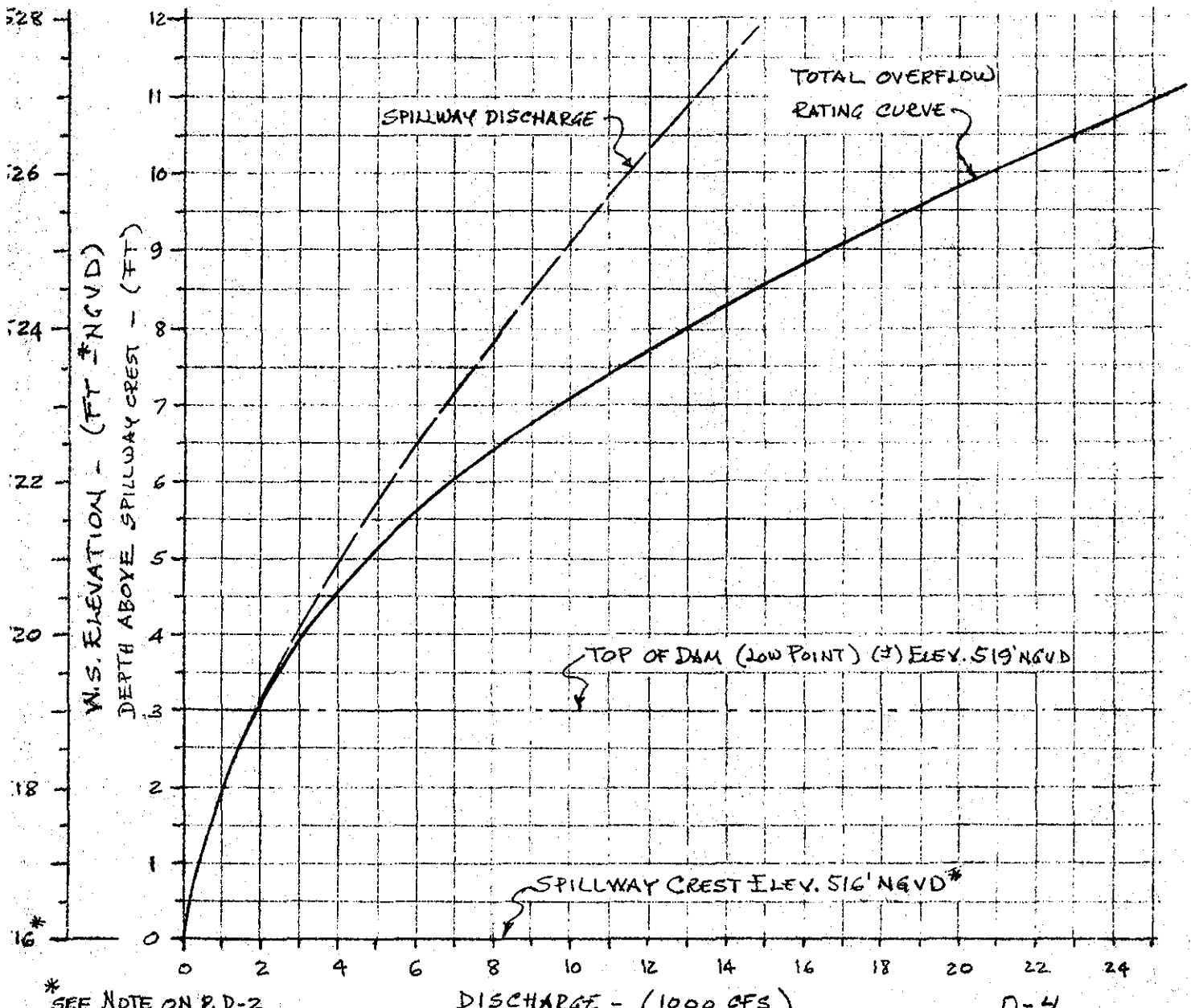
$(Q_{HI})_2 = 3 \times 40 \times (H-6.18)^{3/2} = \underline{120 (H-6.18)^{3/2}}$ $H > 8.9'$

9') SECTION JJ :

$$Q_{JJ} = \tfrac{2}{3} \times 2 \times 2.5 (H - 8.9)^{3/2} = 3.33 (H - 8.9)^{3/2}$$

THEREFORE, THE TOTAL OUTFLOW IS APPROXIMATED BY THE SUM OF ALL THE APPLICABLE FORMULAE ON ITEMS (1') TO (9').

(ii) WARREN POND DAM - OUTFLOW RATING CURVE



*SEE NOTE ON P. D-2

b) SURCHARGE HEIGHT TO PASS PEAK INFLOWS (Q_p & Q'_p)

i) @ Q_{p_1} = PMF ≅ 24000 CFS $H_1 \cong 10.7'$ SAY, $H_1 = \underline{11'}$

ii) @ Q'_{p_1} = ½ PMF ≅ 12000 CFS $H'_1 \cong \underline{7.7'}$

c) EFFECT OF SURCHARGE STORAGE - PEAK OUTFLOWS

i) AVE LAKE AREA WITHIN EXPECTED SURCHARGE ($\bar{A}$)

1') LAKE AREA AT FLOW LINE (EL. 516' NGVD): $A^*_{WL} \cong 9^{AC}$
2') AREA AT CONTOUR 520' NGVD (MSL)* $A_{520} \cong 13^{AC}$
3') AREA AT CONTOUR 530' NGVD (MSL)* $A_{530} \cong 17^{AC}$

∴ AREA AT ELEV. 527' NGVD (± MAX. EXPECTED SURCH.): $A_{527} \cong 16^{AC}$
AVE AREA WITHIN EXPECTED SURCHARGE: $\bar{A} \cong \underline{14}^{AC}$ (BY GRAPHICAL INTERPOLATION; ± $A_{521.4}$)

*NOTE: AREAS FROM USGS STAFFORD SPRINGS, CT. QUAD. SHEET (SCALE 1"=2000')

ii) PEAK OUTFLOWS (Q_{P_3} & Q'_{P_3})

BECAUSE THE LAKE AREA AND CONSEQUENTLY, THE SURCHARGE STORAGE OF WARREN POND ARE RELATIVELY SMALL, NO APPRECIABLE REDUCTION TO THE PEAK INFLOW IS EXPECTED.

THEREFORE,

$Q_{P_3} \cong Q_{P_1} \cong 24000$ CFS $H_3 \cong 10.7'$ SAY, $H_3 = \underline{11'}$

$Q'_{P_3} \cong Q'_{P_1} \cong 12000$ CFS $H'_3 \cong \underline{7.7'}$

(SEE RATING CURVE P. D-4)

3) SPILLWAY CAPACITY RATIO TO PEAK INFLOWS AND OUTFLOWS

SPILLWAY CAPACITY TO:	SURCH.* H (FT)	W.S. ELEV. (FT-NGVD)	SPILLWAY CAPACITY (CFS)	SPILWY. CAPACITY AS % OF INFLOWS AND OUTFLOWS	
				$Q_{P_1} \equiv Q_{P_3}$ (24000 CFS)	$Q'_{P_1} \equiv Q'_{P_3}$ (12000 CFS)
TOP OF DAM	3	519	1900	7.9	16
½ PMF	7.7	523.7	7700	—	64
PMF	11	527	13000	54	—

*SURCHARGE ABOVE SPILLWAY CREST (ELEV. 516' NGVD)

WARREN POND DAM

II) DOWNSTREAM FAILURE HAZARD

1) POTENTIAL IMPACT AREA

JUST DOWNSTREAM FROM WARREN POND, FURNACE BROOK CROSSES A LARGE PORTION OF THE STAFFORD SPRINGS, CT. COMMERCIAL AND INDUSTRIAL AREA. A CONSIDERABLE NUMBER OF THE BUILDINGS BORDERING THE BROOK HAVE FIRST FLOORS BETWEEN (±) 3.5' AND (±) 11' (THE MAJORITY, INCLUDING THE POST OFFICE, (±) 8') ABOVE THE STREAMBED. APPROX. 2000' D/S FROM WARREN POND (ALSO, D/S FROM A SMALLER POND) THE REACH OF FURNACE BROOK AT BOTH SIDES OF TOLLAND AVE/STAFFORD ST. IS A 30' WIDE CONCRETE LINED RECTANGULAR CHANNEL WITH 8' HIGH WALLS AND (±) 1.7% SLOPE (APPROX. MEASURE BY C.E. ON 4/1/80).

2) FAILURE AT WARREN POND DAM

ASSUME SURCHARGE TO TOP OF DAM (EL. 519 'NGVD)

a) HEIGHT OF DAM*: $H_n = 22'$

b) MID-HEIGHT LENGTH*: $\ell_n \doteq 240'$

c) BREACH WIDTH (SEE NED-ACE D/S DAM FAILURE GUIDELINES)

$W = 0.4 \times 240 = 96'$ ASSUME $W_b = \underline{96'}$

BECAUSE THE LONGEST ABUTMENT TO MID-HEIGHT IS (±) 77' THE ASSUMED BREACH WIDTH WILL OVERLAP A MIN. OF 19' OF SPILLWAY SECTION.

*FROM C.E. MEASUREMENTS ON 4/1/8 BY HLL & R.J.

d) ASSUMED WATER DEPTH AT TIME OF FAILURE: $y_o = \underline{22'}$

e) SPILLWAY DISCHARGE AT TIME OF FAILURE:

i) PREVIOUS TO FAILURE: $Q_s = 1900$ CFS (SEE P. D-6)
ii) AFTER FAILURE (REMAIN. SPWY - $L \approx 94'$): $Q_s' = 1600$ CFS

f) BREACH OUTFLOW (SEE NED-ACE GUIDELINES)

$$Q_b \approx \tfrac{8}{27} W_b \sqrt{g}\, y_o^{3/2} = 16700 \text{ CFS}$$

g) PEAK FAILURE OUTFLOW (Q_{p_1}) TO FURNACE BROOK:

$$Q_{p_1} = Q_s' + Q_b = 18300 \text{ CFS} \quad \text{SAY, } Q_{p_1} = \underline{18000} \text{ CFS}$$

3) FLOOD DEPTH* IMMEDIATELY D/S FROM DAM:

$$y \approx 0.44\, y_o = 9.7' \quad \text{SAY, } y \approx \underline{10'}$$

*(FROM RETREATING WAVE THEORY APPLIED TO DAM FAILURE)

4) ESTIMATE OF D/S FAILURE CONDITIONS AT POTENTIAL IMPACT AREA

(SEE NED-ACE GUIDELINES FOR ESTIMATING D/S FAILURE HYDROGRAPHS)

a) CHANNEL D/S FROM WARREN POND DAM.

i) TO D/S POND (UNNAMED) – (±)1800' ASSUME WL CONTROLLED BY OVERFLOW AT THIS SMALL DAM OF NORMAL POOL ELEV. 492' NGVD.

ACTUAL DIMENSIONS/DETAIL OF THIS D/S DAM ARE NOT AVAILABLE. HOWEVER, ASSUME A TRAPEZOIDAL OVERFLOW SECTION (FROM USGS QUAD. SHEET) (±) 150' LONG AND 2.5^H AND 10^H TO 1^V SIDE SLOPES. ASSUME AN OVERALL DISCHARGE COEFFICIENT C = 2.7 AND EQUIVALENT

LENGTHS FOR THE SLOPING SIDES. - THEREFORE, THE OVERFLOW IS APPROXIMATED BY:

$Q = 400 H^{3/2} + 23 H^{5/2}$ AND NO STORAGE EFFECT. ($Q_{P_1} \doteq Q_{P_3}$)

∴ 1') @ $Q_S \doteq 1900^{cfs}$ $(Y_S)_1 \doteq 2.6'$ (PREV. TO FAILURE)

2') @ $Q_{P_1} \doteq 18000^{cfs}$ $(Y_1)_1 = (Y_3)_1 \doteq 9.5'$ (AFTER FAILURE)

NOTE: ONE INDUSTRIAL STRUCTURE W/FF ELEV. (±) 10' ABOVE THE CHANNEL IS LOCATED IN THIS CHANNEL REACH.

ii) CHANNEL D/S FROM THE SMALL (UNNAMED) POND

ASSUME THE CONCRETE LINED RECTANGULAR CHANNEL SECTION DESCRIBED IN SECT. (II, 1) p. D-7 AS TYPICAL WITH THE SIDES ABOVE THE 8' LINED WALLS FORMED BY THE WALLS OF ADJACENT BUILDINGS (±) 8' AWAY FROM THE CHANNEL (i.e. (±) 46' APART).

ASSUME: $n = 0.013$ FOR DEPTHS $\leq 8'$ ($b = 30'$) AND,
$n = 0.018$ FOR DEPTHS $> 8'$ ($b \doteq 46'$)
$S_o \doteq 1.7\%$
NO APPRECIABLE CHANNEL STORAGE ($Q_{P_1} \doteq Q_{P_3}$)

∴ 1') @ $Q_S \doteq 1900^{cfs}$ $(Y_S)_2 \doteq 2.5'$ (PREV. TO FAILURE)

2') @ $Q_{P_1} \doteq 18000^{cfs}$ $(Y_1)_2 = (Y_3)_2 \doteq 13'$ (AFTER FAILURE)

b) RAISE IN STAGE AT IMPACT AREA: $\Delta Y \doteq 10.5'$

III) SELECTION OF TEST FLOOD

1) CLASSIFICATION OF DAM ACCORDING TO NED-ACE GUIDELINES:

a) SIZE: *STORAGE (MAX) $\simeq$ 135 AC-FT ($50 < S < 1000$ AC-FT)
HEIGHT $\simeq$ 22' ($H < 25$ FT)

*STORAGE: C.E. ESTIMATED BY $S \simeq .5AH = .5 \times 12 \times 22 \simeq 132$ AC-FT ($A \simeq 12$ AC @ TOP OF DAM); ALSO, BY GRAPHICAL EXTRAPOLATION AND BY CORRELATION W/ DATA ON U.S.ACE INVENTORY OF DAMS, DATED 1/23/80, p. 36: $S_{NORM} \simeq 100$ AC-FT

HEIGHT: SEE p. D-7

∴ SIZE CLASSIFICATION: SMALL

b) HAZARD POTENTIAL: AS A RESULT OF THE D/S FAILURE ANALYSIS AND IN VIEW OF THE IMPACT THAT FAILURE OF WARREN POND DAM MAY HAVE ON THE POTENTIAL IMPACT AREA (p. D-7), THE DAM IS CLASSIFIED AS HAVING:

HAZARD CLASSIFICATION: HIGH

2) TEST FLOOD: 1/2 PMF = 12000 CFS

THIS SELECTION IS BASED ON THE RESULTS OF THE PREVIOUS ANALYSIS AND CLASSIFICATION.

WARREN POND DAM

IV) SUMMARY

1) TEST FLOOD = ½ PMF ≈ 12000 CFS
(PARALLEL COMPUTATIONS HAVE BEEN MADE FOR PMF ≈ 24000 CFS AND ARE ALSO SUMMARIZED BELOW)

2) PERFORMANCE AT PEAK FLOOD CONDITIONS:
a) PEAK INFLOWS/OUTFLOWS:
$Q_{P_1} \approx Q_{P_3}$ = PMF ≈ 24000 CFS $Q_{P_1}' \approx Q_{P_3}'$ = ½ PMF ≈ 12000 CFS

b) SPILLWAY CAPACITY (SEE TABLE P.D-6):
i) TO TOP OF DAM (H=3'): $(Q_S)_1$ = 1900 CFS (7.9% OF Q_{P_3}; 16% OF Q_{P_3}')
ii) TO ½ PMF SURCHARGE: (H=7.7'): $(Q_S)_2$ = 7700 CFS (64% OF Q_{P_3}')
iii) TO PMF SURCHARGE: (H=11'): $(Q_S)_3$ = 13000 CFS (54% OF Q_{P_3})

c) PERFORMANCE:
i) @ TEST FLOOD: OVERTOPPED (±) 4.7' (W.S. EL. 523.7' NGVD)
ii) @ PMF : OVERTOPPED (±) 8' (W.S. EL. 527' NGVD)

3) DOWNSTREAM FAILURE CONDITIONS:
a) PEAK FAILURE OUTFLOW: $Q_{P_1} \approx$ 18000 CFS
b) FLOOD DEPTH IMMEDIATELY D/S FROM DAM: $Y_0 \approx$ 10'
c) CONDITIONS AT THE INITIAL IMPACT AREA (FURNACE BROOK):
i) Y/S FROM SMALL (UNNAMED) POND:
STAGE BEFORE FAILURE: $(Y_S)_1 \approx$ 2.6' (Q_S = 1900 CFS)
STAGE AFTER FAILURE: $(Y_3)_1 \approx$ 9.5' ($Q_{P_3} \approx$ 18000 CFS)
RAISE IN STAGE AFTER FAILURE: ΔY_1 = 6.9'
ii) D/S FROM SMALL (UNNAMED) POND (LINED CHANNEL):
STAGE BEFORE FAILURE: $(Y_S)_2 \approx$ 2.5' (Q_S = 1900 CFS)
STAGE AFTER FAILURE: $(Y_3)_2 \approx$ 13' (Q_S = 18000 CFS)
RAISE IN STAGE AFTER FAILURE: $\Delta Y_2 \approx$ 10.5'

PRELIMINARY GUIDANCE

FOR ESTIMATING

MAXIMUM PROBABLE DISCHARGES

IN

PHASE I DAM SAFETY

INVESTIGATIONS

New England Division
Corps of Engineers

March 1978

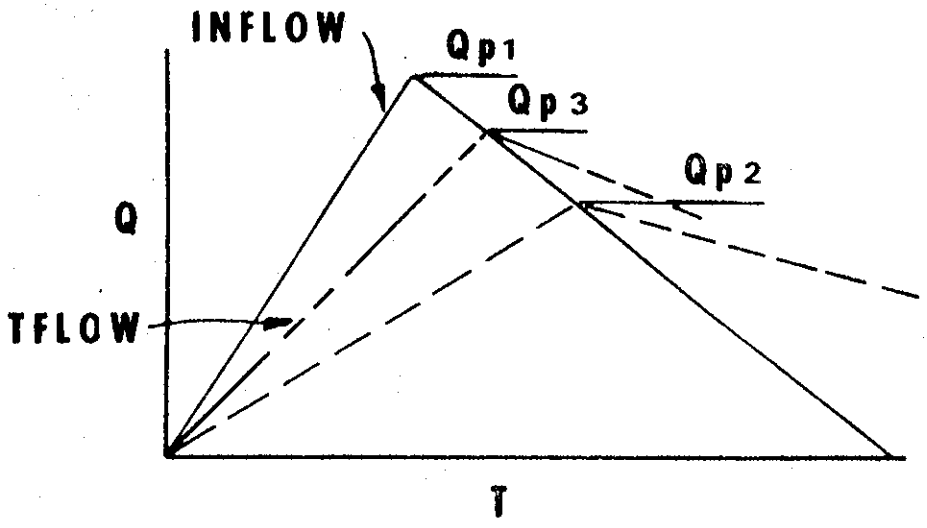
MAXIMUM PROBABLE FLOOD INFLOWS
NED RESERVOIRS

	Project	Q (cfs)	D.A. (sq. mi.)	MPF cfs/sq. mi.
1.	Hall Meadow Brook	26,600	17.2	1,546
2.	East Branch	15,500	9.25	1,675
3.	Thomaston	158,000	97.2	1,625
4.	Northfield Brook	9,000	5.7	1,580
5.	Black Rock	35,000	20.4	1,715
6.	Hancock Brook	20,700	12.0	1,725
7.	Hop Brook	26,400	16.4	1,610
8.	Tully	47,000	50.0	940
9.	Barre Falls	61,000	55.0	1,109
10.	Conant Brook	11,900	7.8	1,525
11.	Knightville	160,000	162.0	987
12.	Littleville	98,000	52.3	1,870
13.	Colebrook River	165,000	118.0	1,400
14.	Mad River	30,000	18.2	1,650
15.	Sucker Brook	6,500	3.43	1,895
16.	Union Village	110,000	126.0	873
17.	North Hartland	199,000	220.0	904
18.	North Springfield	157,000	158.0	994
19.	Ball Mountain	190,000	172.0	1,105
20.	Townshend	228,000	106.0(278 total)	820
21.	Surry Mountain	63,000	100.0	630
22.	Otter Brook	45,000	47.0	957
23.	Birch Hill	88,500	175.0	505
24.	East Brimfield	73,900	67.5	1,095
25.	Westville	38,400	99.5(32 net)	1,200
26.	West Thompson	85,000	173.5(74 net)	1,150
27.	Hodges Village	35,600	31.1	1,145
28.	Buffumville	36,500	26.5	1,377
29.	Mansfield Hollow	125,000	159.0	786
30.	West Hill	26,000	28.0	928
31.	Franklin Falls	210,000	1000.0	210
32.	Blackwater	66,500	128.0	520
33.	Hopkinton	135,000	426.0	316
34.	Everett	68,000	64.0	1,062
35.	MacDowell	36,300	44.0	825

MAXIMUM PROBABLE FLOWS BASED ON TWICE THE STANDARD PROJECT FLOOD (Flat and Coastal Areas)

	River	SPF (cfs)	D.A. (sq. mi.)	MPF (cfs/sq. mi.)
1.	Pawtuxet River	19,000	200	190
2.	Mill River (R.I.)	8,500	34	500
3.	Peters River (R.I.)	3,200	13	490
4.	Kettle Brook	8,000	30	530
5.	Sudbury River.	11,700	86	270
6.	Indian Brook (Hopk.)	1,000	5.9	340
7.	Charles River.	6,000	184	65
8.	Blackstone River.	43,000	416	200
9.	Quinebaug River	55,000	331	330

ESTIMATING EFFECT OF SURCHARGE STORAGE ON MAXIMUM PROBABLE DISCHARGES



STEP 1: Determine Peak Inflow (Qp_1) from Guide Curves.

STEP 2: a. Determine Surcharge Height To Pass "Qp_1".

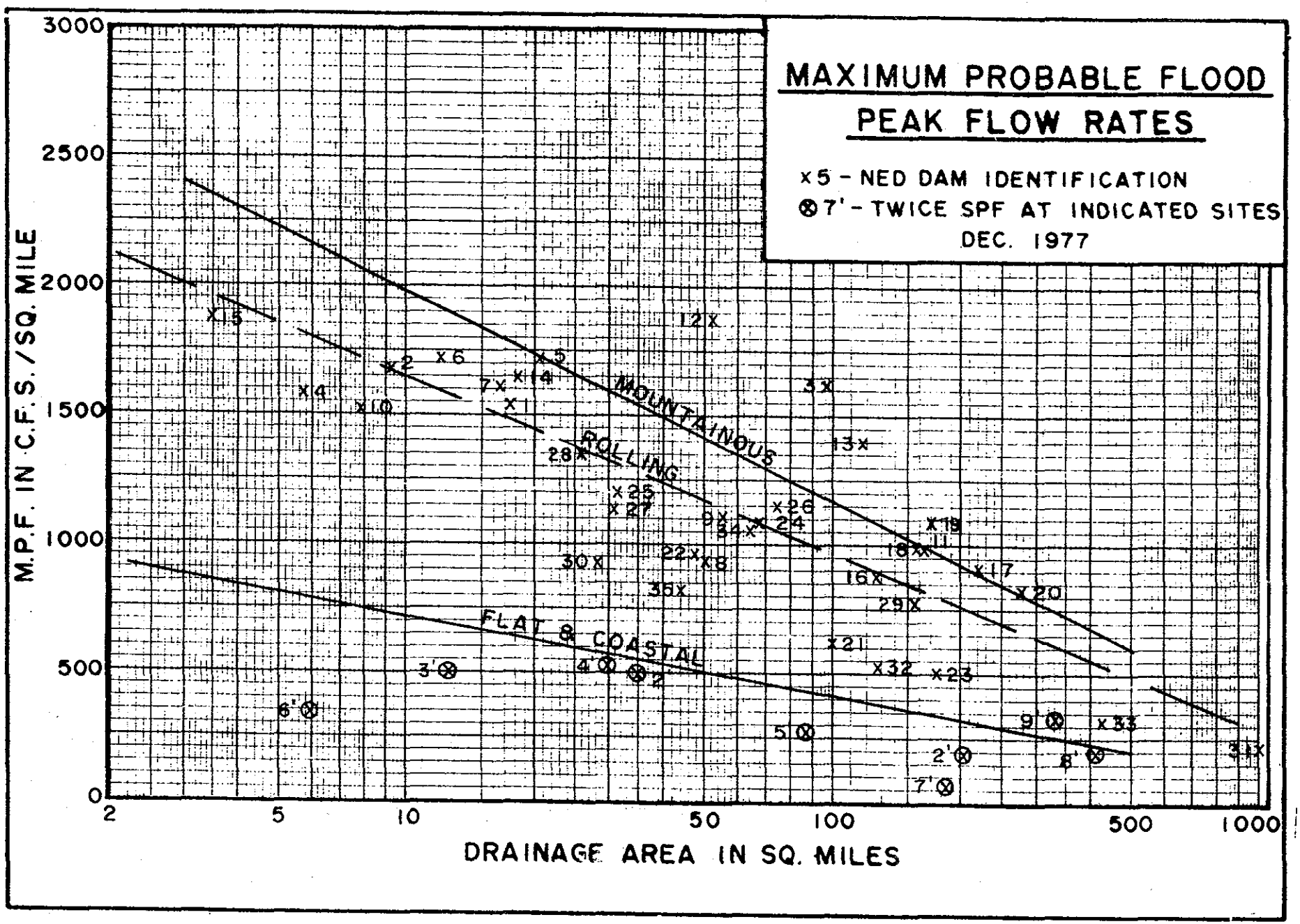
b. Determine Volume of Surcharge ($STOR_1$) In Inches of Runoff.

c. Maximum Probable Flood Runoff In New England equals Approx. 19", Therefore:

$$Qp_2 = Qp_1 \times \left(1 - \frac{STOR_1}{19}\right)$$

STEP 3: a. Determine Surcharge Height and "$STOR_2$" To Pass "Qp_2"

b. Average "$STOR_1$" and "$STOR_2$" and Determine Average Surcharge and Resulting Peak Outflow "Qp_3".


MAXIMUM PROBABLE FLOOD
PEAK FLOW RATES
x5 - NED DAM IDENTIFICATION
⊗7' - TWICE SPF AT INDICATED SITES
DEC. 1977
M.P.F. IN C.F.S./SQ. MILE
DRAINAGE AREA IN SQ. MILES
3000
2500
2000
1500
1000
500
0
2
5
10
50
100
500
1000
MOUNTAINOUS
ROLLING
FLAT & COASTAL
x15
x4
x2
x6
x10
x3
7x
x14
x1
12x
3x
13x
28x
x25
x27
x26
9x
34x
x24
x19
18x
x11
x17
x20
22x
x8
30x
16x
35x
29x
x21
x32
x23
3'⊗
4'⊗
2
6'⊗
5⊗
9'⊗
x33
2'⊗
8'⊗
7'⊗
31x

SURCHARGE STORAGE ROUTING SUPPLEMENT

STEP 3: a. Determine Surcharge Height and "$STOR_2$" To Pass "Qp_2"

b. Avg "$STOR_1$" and "$STOR_2$" and Compute "Qp_3".

c. If Surcharge Height for Qp_3 and "$STOR_{AVG}$" agree O.K. If Not:

STEP 4: a. Determine Surcharge Height and "$STOR_3$" To Pass "Qp_3"

b. Avg. "Old $STOR_{AVG}$" and "$STOR_3$" and Compute "Qp_4"

c. Surcharge Height for Qp_4 and "New $STOR_{Avg}$" should Agree closely

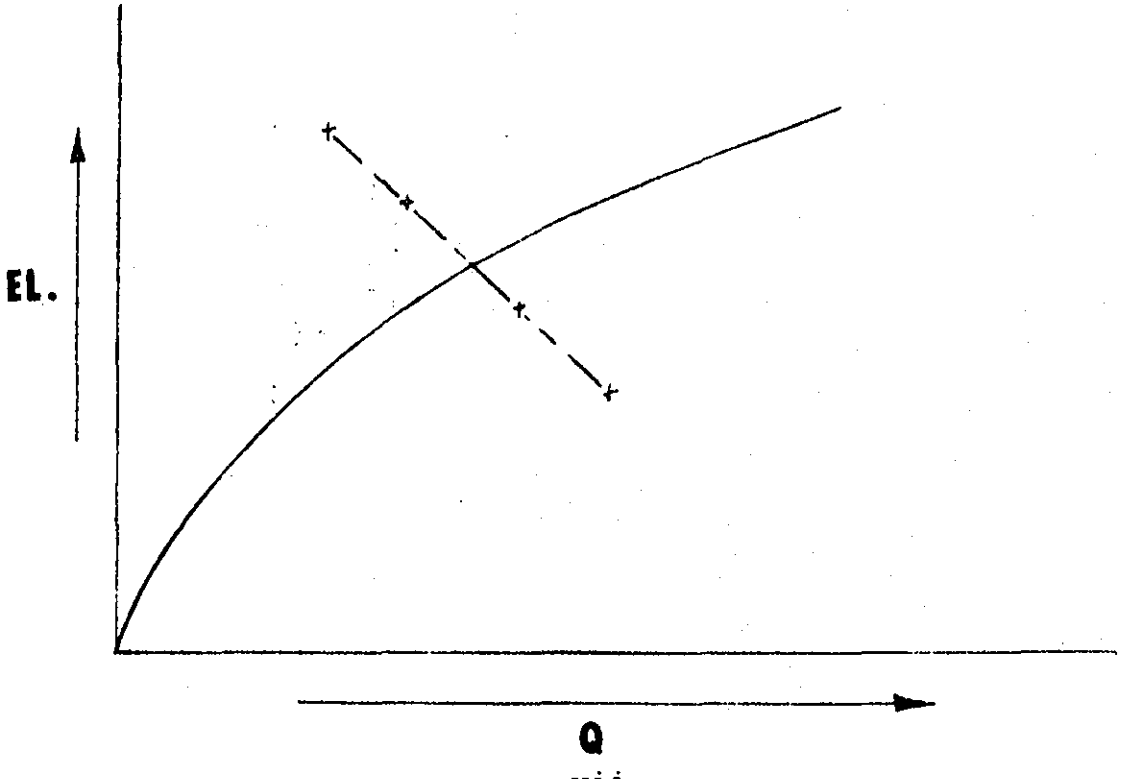
SURCHARGE STORAGE ROUTING ALTERNATE

$$Q_{p2} = Q_{p1} \times \left(1 - \frac{STOR}{19}\right)$$

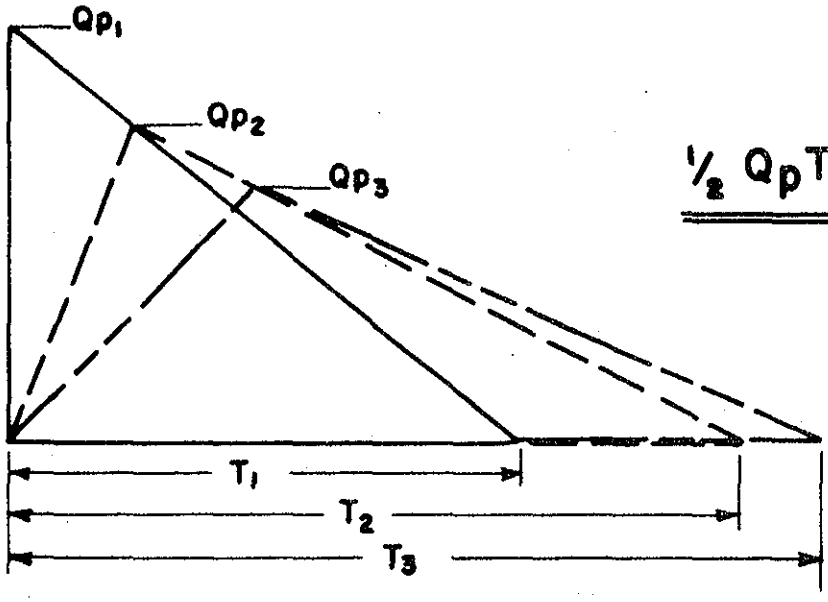
$$Q_{p2} = Q_{p1} - Q_{p1}\left(\frac{STOR}{19}\right)$$

FOR KNOWN Q_{p1} AND 19'' R.O.

Q_{p2}	STOR	EL.



"RULE OF THUMB" GUIDANCE FOR ESTIMATING DOWNSTREAM DAM FAILURE HYDROGRAPHS



$\frac{1}{2} Q_p T = 12 S$

STEP 1: DETERMINE OR ESTIMATE RESERVOIR STORAGE (S) IN AC-FT AT TIME OF FAILURE.

STEP 2: DETERMINE PEAK FAILURE OUTFLOW (Q_{p1}).

$$Q_{p_1} = \frac{8}{27} W_b \sqrt{g} Y_o^{3/2}$$

W_b = BREACH WIDTH - SUGGEST VALUE NOT GREATER THAN 40% OF DAM LENGTH ACROSS RIVER AT MID HEIGHT.

Y_o = TOTAL HEIGHT FROM RIVER BED TO POOL LEVEL AT FAILURE.

STEP 3: USING USGS TOPO OR OTHER DATA, DEVELOP REPRESENTATIVE STAGE-DISCHARGE RATING FOR SELECTED DOWNSTREAM RIVER REACH.

STEP 4: ESTIMATE REACH OUTFLOW (Q_{p2}) USING FOLLOWING ITERATION.

A. APPLY Q_{p1} TO STAGE RATING, DETERMINE STAGE AND ACCOPMANYING VOLUME (V_1) IN REACH IN AC-FT. (NOTE: IF V_1 EXCEEDS 1/2 OF S, SELECT SHORTER REACH.)

B. DETERMINE TRIAL Q_{p2}.

$$Q_{p_2}(\text{TRIAL}) = Q_{p_1}\left(1 - \frac{V_1}{S}\right)$$

C. COMPUTE V_2 USING Q_{p2} (TRIAL).

D. AVERAGE V_1 AND V_2 AND COMPUTE Q_{p2}.

$$Q_{p_2} = Q_{p_1}\left(1 - \frac{V_{AVG}}{S}\right)$$

STEP 5: FOR SUCCEEDING REACHES REPEAT STEPS 3 AND 4.

APRIL 1978

APPENDIX E

INFORMATION AS CONTAINED IN THE NATIONAL INVENTORY OF DAMS